DOE/RL-2000-38
Rev. 0

200-TW-1 Scavenged Waste Group Operable Unit and 200-TW-2 Tank Waste Group Operable Unit RI/FS Work Plan

United States
Department of Energy

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United States Department of Energy

P.O. Box 550, Richland, Washington 99352

EXECUTIVE SUMMARY

This work plan supports the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* remedial investigation/feasibility study (RI/FS) activities for the 200-TW-1 Scavenged Waste Group Operable Unit (OU) and the *Resource Conservation and Recovery Act of 1976* facility investigation/corrective measures study activities for the 200-TW-2 Tank Waste Group OU. The 200-TW-1 and 200-TW-2 OUs are located near the center of the Hanford Site in south-central Washington State. The 200-TW-1 OU consists of 35 waste sites and 1 associated unplanned release site as defined in the *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (Implementation Plan) (DOE-RL 1999). The 200-TW-2 OU consists of 27 waste sites and 1 associated unplanned release site. Representative sites were identified for each OU. The remedial investigation focuses on these representatives sites, which are the 216-B-46 Crib and the 216-T-26 Crib for the 200-TW-1 OU, and the 216-B-5 Reverse Well, the 216-B-7A&B Cribs, and the 216-B-38 Trench for the 200-TW-2 OU.

This work plan documents OU-specific background information, defines OU-specific characterization and assessment activities and schedules based on the framework established in the Implementation Plan, and identifies the steps required to complete the RI/FS process for the OUs. A data quality objectives (DQO) process was conducted for these OUs to define the chemical and radiological constituents to be characterized and to specify the number, type, and location of samples to be collected at representative sites within the OU. The results of the DQO process form the basis for the work plan and the associated sampling and analysis plan (SAP) included in Appendix A. The SAP includes an OU-specific quality assurance project plan and a field sampling plan for implementing the characterization activities in the field.

The 200-TW-1 OU waste sites received scavenged waste from the Uranium Recovery Project and the ferrocyanide processes at the 221/224-U Plant. The 200-TW-2 OU waste sites received tank waste from first- and second-cycle decontamination processes associated with the bismuth-phosphate process at the B and T Plants.

Preliminary conceptual contaminant distribution models were developed for the 200-TW-1 and 200-TW-2 OUs in the *Waste Site Grouping for 200 Areas Soil Investigations* report (DOE-RL 1997). The preliminary models were updated with conceptual contaminant distribution models of representative sites in this work plan based on physical conditions and the nature and extent of contamination at representative sites.

The following statements are general conclusions regarding the conceptual contaminant distribution model for these waste groups.

- Effluent discharged to waste sites in these OUs consisted of high salt, neutral/basic, and low organic waste with high levels of fission products.

- Waste sites generally received small quantities of effluent. Of 64 waste sites in the 2 OUs, effluent volumes exceeded soil pore volumes at only 8 sites, including 3 representative sites (216-B-46, 216-T-26, and 216-B-7A&B). Contaminants at the 216-B-5 Reverse Well were injected directly into the aquifer and vadose zone just above the aquifer.

- Effluent and mobile contaminants migrated vertically beneath the waste sites after release. Lateral spreading of liquids and contaminants may occur associated with the sandy sequence of the Hanford formation and the Plio-Pleistocene unit/early Palouse soil. At waste sites where effluent volumes exceed soil pore volumes, and where liquid waste was injected directly into or near the aquifer, groundwater has been impacted.

- Contaminants such as cesium and plutonium normally adsorb strongly onto Hanford Site sediments because they have large distribution coefficients (K_ds). These immobile contaminants should be detected near points of release in the vadose zone because of their large K_d. Contaminants with low K_ds (e.g., nitrite and tritium) are not readily adsorbed on soil particles and migrate to greater depths within the vadose zone.

- Contaminant concentrations generally decrease with depth; however, elevated concentrations associated with finer grained facies may be detected.

Potential receptors (human and ecological) may be exposed to the affected media through several exposure pathways, including inhalation, ingestion, and direct exposure to external gamma radiation. Potential human receptors include current and future site workers. Potential ecological receptors include terrestrial plants and animals. Future impacts to humans are largely dependent on the land use. The type of future land use is not certain at this time, but some type of restricted land use for the 200 Areas is favored by the U.S. Department of Energy, the U.S. Environmental Protection Agency, and the Washington State Department of Ecology (the Tri-Parties). All the sites within the 200-TW-1 and 200-TW-2 OUs are located within the exclusive land-use boundary identified in the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE 1999a) and the associated *Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE 1999b).

Characterization activities planned to collect the required data identified in the DQO process include borehole drilling and sampling and geophysical logging using spectral gamma and neutron moisture tools. Sample analysis will be conducted by an offsite laboratory under a contract-required quality program. The sampling strategy is designed to provide access to potentially contaminated subsurface areas. Sample collection will be guided by field screening and a sampling scheme that identifies critical sampling depths.

The SAP directs sampling and analysis activities that will be performed to characterize the vadose zone at the five representative waste sites. The data will be used to refine the conceptual contaminant distribution models, support an assessment of risk, and evaluate a range of remedial alternatives for waste sites in these OUs. The scope of activities described in the work plan and SAP involves sampling and geophysical logging of deep boreholes and geophysical logging of existing boreholes to obtain additional information on the distribution of contamination. Boreholes will be drilled to groundwater at the 216-T-26 Crib, the 216-B-7A Crib, and the 216-B-38 Trench. Boreholes will be drilled through the waste sites; soil samples will be collected and analyzed for radiological and nonradiological contaminants of concern and

selected physical properties. During the DQO process, an evaluation of existing data showed that no additional soil samples are required for the RI/FS process at the 216-B-46 Crib and the 216-B-5 Reverse Well. However, existing boreholes in the vicinity of these two sites will be geophysically logged to provide addition information. Table ES-1 summarizes the sample collection requirements for the representative waste sites to be investigated.

Table ES-1. Summary of Projected Sample Collection Requirements for the 200-TW-1 and 200-TW-2 Operable Units.

	216-T-26 Crib	216-B-7A Crib	216-B-38 Trench	Project Total
Chemical Parameters				
Maximum number of characterization samples	11	13	11	35
Details of quality control samples				
Collocated duplicates	1	1	1	3
Splits	1	1	1	3
Equipment blanks	1	1	1	3
Approximate number of field quality control samples	3	3	3	9
Approximate total number of samples	14	16	14	44
Physical Properties				
Bulk density, moisture content, particle size distribution	5	4	3	12

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ACRONYMS

amsl	above mean sea level
AAMS	aggregate area management study
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
BHI	Bechtel Hanford, Inc.
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CMS	corrective measures study
COC	contaminant of concern
COPC	contaminant of potential concern
CPP	CERCLA past-practice
DOE	U.S. Department of Energy
DQA	data quality assessment
DQO	data quality objective
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FS	feasibility study
GRA	general response action
HASP	health and safety plan
HPGe	high-purity germanium
IDW	investigation-derived waste
ILCR	incremental lifetime cancer risk
K_d	distribution coefficient
MTCA	*Model Toxics Control Act*
NEPA	*National Environmental Policy Act of 1969*
OU	operable unit
PCB	polychlorinated biphenyl
PNNL	Pacific Northwest National Laboratory
PRG	preliminary remediation goal
PUREX	Plutonium/Uranium Extraction
QRA	qualitative risk assessment
RAO	remedial action objective
RAWP	remedial action work plan
RCRA	*Resource Conservation and Recovery Act of 1976*
RDR	remedial design report
REDOX	Reduction/Oxidation
RESRAD	RESidual RADioactivity
RI	remedial investigation
ROD	record of decision
RPP	RCRA past-practice
SAP	sampling and analysis plan
SCA	soil contamination area

Acronyms

SGL	spectral gamma-ray logging
SST	single-shell tank
TBP	tributyl phosphate
Tri-Parties	U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Energy
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TRU	transuranic
TSD	treatment, storage, and/or disposal
UPR	unplanned release
URP	Uranium Recovery Project
WAC	*Washington Administrative Code*
WIDS	Waste Information Data System

METRIC CONVERSION CHART

The following conversion chart is provided to aid the reader in conversion.

Into Metric Units			Out of Metric Units		
If You Know	*Multiply By*	*To Get*	*If You Know*	*Multiply By*	*To Get*
Length			**Length**		
inches	25.4	millimeters	millimeters	0.039	inches
inches	2.54	centimeters	centimeters	0.394	inches
feet	0.305	meters	meters	3.281	feet
yards	0.914	meters	meters	1.094	yards
miles	1.609	kilometers	kilometers	0.621	miles
Area			**Area**		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.093	sq. meters	sq. meters	10.76	sq. feet
sq. yards	0.0836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.6	sq. kilometers	sq. kilometers	0.4	sq. miles
acres	0.405	hectares	hectares	2.47	acres
Mass (weight)			**Mass (weight)**		
ounces	28.35	grams	grams	0.035	ounces
pounds	0.454	kilograms	kilograms	2.205	pounds
ton	0.907	metric ton	metric ton	1.102	ton
Volume			**Volume**		
teaspoons	5	milliliters	milliliters	0.033	fluid ounces
tablespoons	15	milliliters	liters	2.1	pints
fluid ounces	30	milliliters	liters	1.057	quarts
cups	0.24	liters	liters	0.264	gallons
pints	0.47	liters	cubic meters	35.315	cubic feet
quarts	0.95	liters	cubic meters	1.308	cubic yards
gallons	3.8	liters			
cubic feet	0.028	cubic meters			
cubic yards	0.765	cubic meters			
Temperature			**Temperature**		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius	Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity			**Radioactivity**		
picocuries	37	millibecquerel	millibecquerel	0.027	picocuries

1.0 INTRODUCTION

This work plan supports the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) remedial investigation/feasibility study (RI/FS) activities for the 200-TW-1 Scavenged Waste Group Operable Unit (OU) and the *Resource Conservation and Recovery Act of 1976* (RCRA) facility investigation/corrective measures study (RFI/CMS) activities for the 200-TW-2 Tank Waste Group OU. The general RI/FS process is described in the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988). The general RFI/CMS process is described in the Corrective Action Plan (EPA 1994b). The application of these processes in the 200 Areas is described in the *200 Areas Remedial Investigation/Feasibility Study Implementation Plan - Environmental Restoration Program* (hereinafter referred to as the Implementation Plan) (DOE-RL 1999); the implementation plan is summarized in Section 1.1 of this work plan. The 200 Areas is one of four areas on the Hanford Site that are on the U.S. Environmental Protection Agency's (EPA's) National Priorities List under CERCLA.

The 200-TW-1 and 200-TW-2 OUs are located near the center of the Hanford Site in south-central Washington State. The 200-TW-1 OU consists of 35 waste sites and 1 associated unplanned release (UPR) site as defined in the Implementation Plan (DOE-RL 1999). The 200-TW-2 OU consists of 27 waste sites and 1 associated UPR. Characterization of the 200-TW-1 and 200-TW-2 OUs is being addressed in a single work plan because of their similar geographical locations and process histories. Also, the data generated through characterization activities associated with these OUs will support activities in other core projects in the U.S. Department of Energy (DOE), Richland Operations Office's Groundwater/Vadose Zone Integration Project (e.g., River Protection Project and Groundwater Project). Integration of the data collection activities with other projects results in a more efficient and consistent process.

The 200-TW-1 waste sites received scavenged waste from the Uranium Recovery Project (URP) and the ferrocyanide processes at the 221/224-U Plant, which recovered the uranium from the metal waste streams at B and T Plants. The scavenged waste discharges contributed perhaps the largest liquid fraction of contaminants to the ground in the 200 Areas. The 200-TW-2 waste sites received tank waste from first- and second-cycle decontamination processes associated with the bismuth-phosphate process at B and T Plants. These tank wastes contained inorganic anions and cations as well as low levels of radionuclides.

The characterization and remediation of waste sites at the Hanford Site are addressed in the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1998). The schedule of work at the Hanford Site is governed by Tri-Party Agreement milestones. The milestone controlling the schedule for the 200-TW-1 OU is M-13-23, "Submit Scavenged Waste Group Work Plan," August 31, 2000. The milestone controlling the schedule for the 200-TW-2 OU is M-13-24, "Submit Tank Waste Group Work Plan," August 31, 2000. All characterization work for non-tank farm OUs in the 200 Areas is scheduled to be completed by December 31, 2008 (Milestone M-15-00C).

1.1 200 AREAS IMPLEMENTATION PLAN

The Implementation Plan outlines a strategy that is intended to streamline the characterization and remediation of waste sites in the 200 Areas, including CERCLA past-practice (CPP) sites; RCRA past-practice (RPP) sites; and RCRA treatment, storage, and/or disposal (TSD) units. The plan outlines the framework for implementing assessment activities and evaluation of remedial alternatives in the 200 Areas to ensure consistency in documentation, level of characterization, and decision making. A regulatory framework is established in the Implementation Plan to integrate the requirements of RCRA and CERCLA into one standard approach for cleanup activities in the 200 Areas. This approach is illustrated in Figure 1-1. The 200-TW-1 OU consists entirely of CPP sites, with the EPA as the lead regulatory agency. The 200-TW-2 OU consists entirely of RPP sites, with the Washington State Department of Ecology (Ecology) as the lead regulatory agency. Neither OU includes any TSD units. While a single work plan is being prepared to address characterization activities for these OUs, the remainder of the RI/FS and RFI/CMS processes may be conducted on an individual OU basis or combined, as shown in Figure 1-1. For the purposes of this document, the CERCLA terminology will be used consistent with the Implementation Plan.

The Implementation Plan consolidates much of the information normally found in an OU-specific work plan to avoid duplication of this information for each of the 23 OUs in the 200 Areas. The Implementation Plan also lists potential applicable or relevant and appropriate requirements (ARARs) and preliminary remedial action objectives (RAOs), and contains a discussion of potentially feasible remedial technologies that may be employed in the 200 Areas. This work plan references the Implementation Plan for further details on several topics, such as general information on the physical setting and operational history of 200 Area facilities, ARARs, RAOs, and post-work plan activities.

1.2 SCOPE AND OBJECTIVES

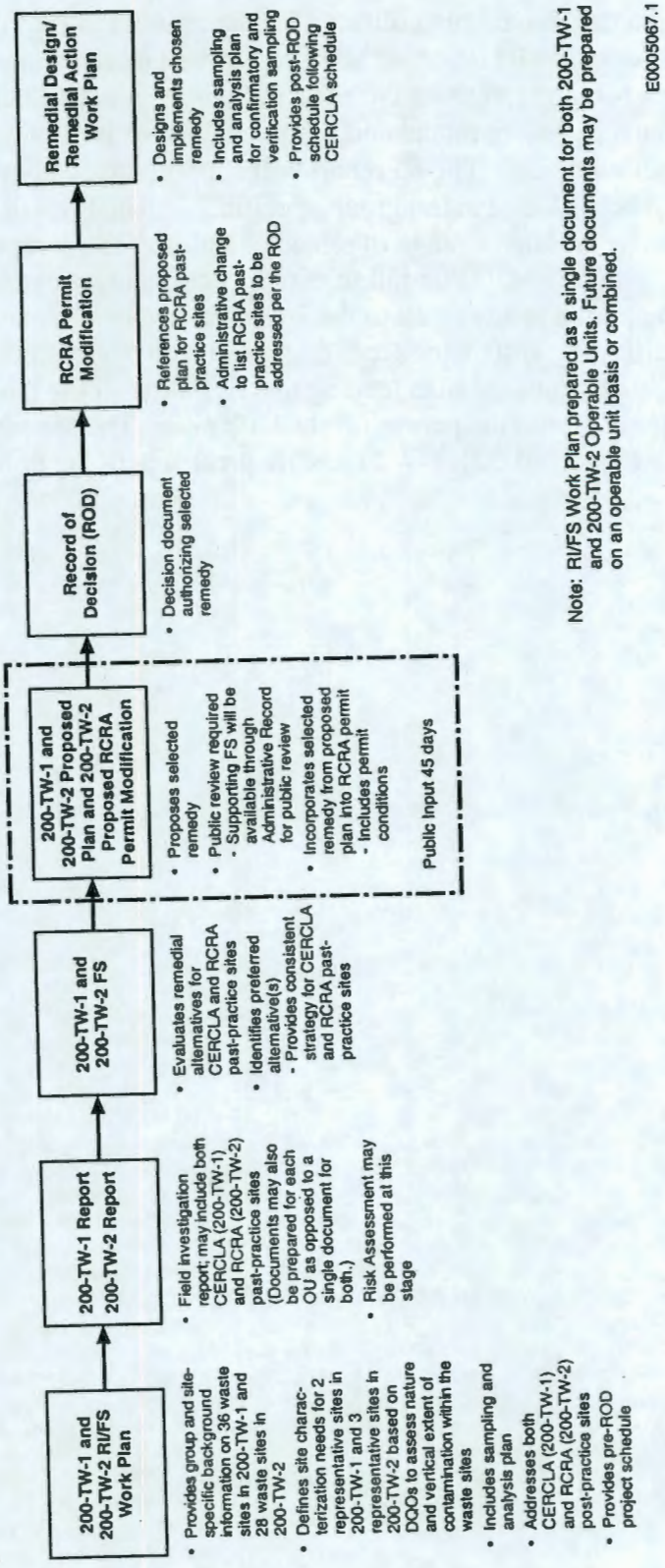
This work plan documents OU-specific background information, defines OU-specific characterization and assessment activities and schedule based on the framework established in the Implementation Plan, and identifies the steps required to complete the RI/FS process for the OUs. Operable unit-specific detail is presented in this work plan, including background information on the waste sites; existing data regarding contamination at the representative waste sites; and the approach that will be used to investigate, characterize, and evaluate the waste sites. A discussion of the RI planning and execution process for each OU is included, along with a schedule for the characterization work. Preliminary remedial action alternatives that are likely to be considered for these OUs are identified in the work plan. These preliminary remedial alternatives will be further developed and agreed to in the FS or CMS, the proposed plan or proposed permit modification, and the eventual record of decision (ROD) or permit modification.

A data quality objective (DQO) process was conducted for these OUs to define the chemical and radiological constituents to be characterized and to specify the number, type, and location of samples to be collected at representative sites within the OU. The results of the DQO process form the basis for the work plan and the associated sampling and analysis plan (SAP) included in

Appendix A. The SAP includes an OU-specific quality assurance project plan and a field sampling plan for implementing the characterization activities in the field.

After characterization data have been collected for the representative sites, results will be presented in a group-specific RI report. The RI report will include an evaluation of the characterization data for the representative sites, including an assessment of the accuracy of the preliminary conceptual exposure model and refinement of the preliminary conceptual contaminant distribution model. The RI report will support the evaluation of remedial alternatives that will be included in the group-specific FS. The FS will use the existing and newly collected data to evaluate a range of remedial actions for the representative sites and for the remaining sites within the OU that fall within the contaminant distribution model. Remedial alternatives may be applied at any or all of the waste sites in an OU, and different alternatives may be applied to different waste sites depending on site characteristics. The FS will ultimately support a group-specific proposed plan leading to a ROD for all the waste sites in the OU; the ROD will be incorporated into the permit for the RPP sites. The schedules for assessment activities at the 200-TW-1 and 200-TW-2 OUs are presented in Section 6.0.

Figure 1-1. Regulatory Process for the 200-TW-1 and 200-TW-2 Operable Units (Modified from DOE-RL 1999).



2.0 BACKGROUND AND SETTING

This section describes the 200-TW-1 Scavenged Waste Group and the 200-TW-2 Tank Waste Group OUs. Waste site information and the hydrogeologic framework associated with these OUs are described for the purpose of providing a fundamental understanding of the physical setting and potential impacts on the environment. Information is presented in a logical manner beginning with the physical setting, waste site description and history, and waste-generating processes. The section ends with a detailed discussion of each representative site. The representative sites will be characterized under this work plan and as guided by the analogous unit investigation strategy defined in the Implementation Plan (DOE-RL 1999). Summary information is provided for waste sites that will not be immediately characterized but will be addressed by future planning efforts. Information in this section is summarized from the following reports:

- *Waste Site Grouping for 200 Areas Soil Investigations* (DOE-RL 1997)
- *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (DOE-RL 1999)
- *B Plant Source Aggregate Area Management Study Report* (DOE-RL 1993b)
- *Subsurface Conditions Description of the B-BX-BY Waste Management Area* (Wood et al. 2000)
- *T Plant Source Aggregate Area Management Study Report* (DOE-RL 1993d)
- *Phase I Remedial Investigation Report for 200-BP-1 Operable Unit* (DOE-RL 1993c)
- *200-BP-5 Operable Unit Technical Baseline Report* (Jacques and Kent 1991)
- *216-B-5 Reverse Well Characterization Study* (Smith 1980)
- *Evaluation of Scintillation Probe Profiles from 200 Area Crib Monitoring Wells* (Fecht et al. 1977)
- PNLATLAS Database.

2.1 PHYSICAL SETTING

The following is a synopsis of the geology and hydrology associated with the 200 Areas inclusive of the 200-TW-1 and 200-TW-2 OUs. More detail on the physical setting of the 200 Areas and vicinity is provided in Appendix F of the Implementation Plan (DOE-RL 1999).

2.1.1 Topography

The 200 Area Plateau is the common reference used to describe the broad, flat area that constitutes a local topographic high around the 200 Areas. The plateau is one of the flood bars (i.e., Cold Creek Bar) formed during the cataclysmic flooding events of the Missoula floods (which was the last major flood approximately 13,000 years ago). The northern boundary of the flood bar is defined by an erosional channel that runs east-southeast before turning south just east of the 200 East Area. This erosional channel formed during waning stages of flooding as floodwaters drained from the basin. The northern half of the 200 East Area lies within this ancient flood channel. The southern half of the 200 East Area and most of the 200 West Area are situated on the flood bar. A secondary flood channel running southward off the main channel bisects the 200 West Area. The buried former river and flood channels may provide preferential pathways for groundwater and contaminant movement.

The 200-TW-1 and 200-TW-2 OU waste sites are located in or near the 200 East and 200 West Areas on the plateau. Waste sites in the 200 West Area are situated in a relatively flat area in a secondary flood channel. Surface elevations range from approximately 205 m (673 ft) above mean sea level (amsl) to 217 m (712 ft), and the surface slopes gently to the west. Waste site surface elevations in the 200 East Area and vicinity range from approximately 189 m (620 ft) amsl in the northern portion of the 200 Area to 230 m (755 ft) at waste sites just south of the 200 East Area. The surface within the 200 East Area slopes gently to the northeast.

2.1.2 Geology

The 200-TW-1 and 200-TW-2 OUs are located in the Pasco Basin on the Columbia Plateau. These waste groups are underlain by basalt of the Columbia River Basalt Group and a sequence of suprabasalt sediments. From oldest to youngest, major geologic units of interest are the Elephant Mountain Basalt Member, the Ringold Formation, the Plio-Pleistocene unit, the Hanford formation/Plio-Pleistocene unit (?), and the Hanford formation. The fluvial-lacustrine Ringold Formation is informally divided into several informal units (from oldest to youngest): unit A, lower mud, unit E, and upper unit. It is overlain by a Plio-Pleistocene-aged unit in the 200 West Area consisting of a locally derived subunit that is interpreted to be a weathering surface developed on the top of the Ringold Formation (WHC 1994a, Bjornstad 1990) and an eolian facies (Slate 1996). The eolian facies was originally described as a separate unit called the early "Palouse soil." A recently identified unit of questionable origin, referred to as the Hanford formation/Plio-Pleistocene unit (?), is reported in the northwest corner of the 200 East Area. This unit may be equivalent or partially equivalent to the Plio-Pleistocene or it may represent the earliest ice age flood deposits overlain by a locally thick sequence of fine-grained nonflood deposits (Wood et al. 2000). Glaciofluvial cataclysmic flood deposits of the Hanford formation are present in both the 200 East and 200 West Areas. Hanford formation deposits consist of gravel-dominated and sand-dominated sequences. A generalized stratigraphic column for the 200 East and 200 West Areas is shown in Figure 2-1.

The Elephant Mountain Basalt Member is a medium- to fine-grained tholeiitic basalt with abundant microphenocrysts of plagioclase (DOE 1988). Basalt is overlain by the Ringold Formation in the eastern, southern, and central sections of the 200 East Area and all of the

200 West Area. This formation consists of an interstratified sequence of unconsolidated clay, silt, sand, and granule to cobble gravel deposited by the ancestral Columbia River. These alluvial sediments consist of four major units; these are (from oldest to youngest) the fluvial gravel and sand of unit A, the buried soil horizons and lake deposits of the lower mud sequence, the fluvial sand and gravel of unit E, and the lacustrine mud of the upper unit.

Overlying the Ringold Formation in the 200 West Area is the locally derived subunit of the Plio-Pleistocene unit, which consists of poorly sorted, locally derived, interbedded reworked loess, silt, sand, and basaltic gravel (WHC 1994a). The subunit consists of a lower carbonate-rich paleosol (caliche) and an upper eolian facies. The carbonate-rich section consists of interbedded carbonate-poor and carbonate-rich strata. The upper silty eolian facies was previously interpreted to be early Pleistocene loess and is referred to as the early Palouse soil (Bjornstad 1990). Generally, it is well-sorted quartz-rich/basalt-poor silty sand to sandy silt (BHI 1996).

Where the Ringold Formation and Plio-Pleistocene unit are not present, the Hanford formation/Plio-Pleistocene unit (?) and Hanford formation sediments overlie the basalt. The Hanford formation/Plio-Pleistocene unit (?) is made up of two facies and has only been identified in the 200 East Area near the B-BX-BY Tank Farms. The lower facies overlies basalt and is described in Wood et al. (2000) as loose, unconsolidated sandy gravel to gravelly sand. These gravels contain 50% to 70% basalt and are similar to and often indistinguishable from Hanford formation flood gravels in the absence of the second facies. The second facies consists of an olive brown to olive gray, well-sorted calcareous eolian/overbank silt with laminations, as well as pedogenic structures. However, it has also been observed to be massive and void of any sedimentary or pedogenic structures. The Hanford formation consists of unconsolidated gravel, sand, and silts deposited by cataclysmic floodwaters. These deposits consist of gravel-dominated and sand-dominated facies. The gravel-dominated facies consist of cross-stratified, coarse-grained sands and granule to boulder gravel. The gravel is uncemented and matrix poor. The sand facies consists of well-stratified fine- to coarse-grained sand and granule gravel. Silt in these facies is variable and may be interbedded with the sand. Where the silt content is low, an open-framework texture is common. An upper and lower gravel unit and a middle sand facies are present in the study area.

The cataclysmic floodwaters that deposited sediments of the Hanford formation also locally reshaped the topography of the Pasco Basin. The floodwaters deposited a thick sand and gravel bar that constitutes the higher southern portion of the 200 Areas, informally known as the 200 Area Plateau. In the waning stages of the ice age, these floodwaters also eroded a channel north of the 200 Areas in the area currently occupied by Gable Mountain Pond. These floodwaters removed all of the Ringold Formation from this area and deposited Hanford formation sediments directly over basalt.

Holocene-aged deposits overlie the Hanford formation and are dominated by eolian sheets of sand that form a thin veneer across the site, except in localized areas where the deposits are absent. Surficial deposits consist of very fine- to medium-grained sand to occasionally silty sand. Silty deposits less than 1 m (approximately 3 ft) thick have also been documented at waste

sites where fine-grained windblown material has settled out through standing water over many years.

2.1.3 Vadose Zone

The vadose zone is approximately 104 m (340 ft) thick in the southern section of the 200 East Area and thins to the north to 0.3 m (1 ft) near West Lake. Sediments in the vadose zone are dominated by the Ringold and Hanford Formations. The Hanford formation/Plio-Pleistocene unit (?) may be present in a small area immediately above the basalt beneath the B-BX-BY Tank Farms. Because erosion during cataclysmic flooding removed much of the Ringold Formation north of the central part of the 200 East Area, the vadose zone is dominantly composed of Hanford formation sediments between the northern part of the 200 Areas and Gable Mountain. Areas of basalt also project above the water table north of the 200 East Area. The lower mud sequence is the most significant aquitard in the 200 East Area and can be a significant perching layer.

In the 200 West Area, the vadose zone thickness ranges from 79 m (261 ft) in the southeast corner to 102 m (337 ft) in the northwest corner. Sediments in the vadose zone are the Ringold Formation, the Plio-Pleistocene unit, and the Hanford formation. Erosion during cataclysmic flooding removed some of the Ringold Formation and Plio-Pleistocene unit. Perched water has historically been documented above the Plio-Pleistocene unit at locations in the 200 West Area.

Recharge to the unconfined aquifer within the 200 Areas is from artificial and possibly natural sources. Any natural recharge originates from precipitation. Estimates of recharge from precipitation range from 0 to 10 cm/yr (0 to 4 in./yr) and are largely dependent on soil texture and the type and density of vegetation. Artificial recharge occurred when effluent such as cooling water was disposed of to the ground. Zimmerman et al. (1986) report that between 1943 and 1980, 6.33×10^{11} L (1.67×10^{11} gal) of liquid wastes were discharged to the soil column. Most sources of artificial recharge have been halted. The artificial recharge that does continue is largely limited to liquid discharges from sanitary sewers, 2 state-approved land disposal structures, and 140 small-volume, uncontaminated, miscellaneous streams. One of the approved land disposal structures, the Treated Effluent Disposal Facility (a liquid waste disposal facility), is located 600 m (2,000 ft) east of the 216-B-3C lobe and receives plant-treated liquid wastes from the 200 East and 200 West Area facilities.

While the liquid waste disposal facilities were operating, many localized areas of saturation or near saturation were created in the soil column. With the reduction of artificial recharge in the 200 Areas, the downward flux of moisture in the vadose zone beneath these waste sites has been decreasing. However, the moisture in the vadose zone may be elevated over pre-operational conditions for some time. When unsaturated conditions are reached, the moisture flux to groundwater becomes increasingly less significant as a source of recharge because unsaturated hydraulic conductivities decrease with decreasing moisture content. In the absence of artificial recharge, the potential for recharge from natural precipitation becomes more important as a driving force for any contamination remaining in the vadose zone.

2.1.4 Groundwater

The unconfined aquifer in the 200 Areas occurs within the Hanford formation/Plio-Pleistocene unit (?), the Hanford formation, or the Ringold Formation, depending on location. Groundwater in the unconfined aquifer flows from areas where the water table is higher (west of the Hanford Site) to areas where it is lower, near the Columbia River (PNNL 2000). In the northern half of the 200 East Area, the water table is present within the Hanford formation, except in areas where basalt extends above the water table. Near the B-BX-BY waste management area, the water table occurs within the Hanford formation/Plio-Pleistocene unit (?). In the central and southern sections of the 200 East Area, the water table is located near the contact of the Ringold and Hanford Formations.

Depth to the water table in the vicinity of the 200 East Area ranges from about 54 m (177 ft) near B Pond to over 100 m (328 ft) at the BC Cribs. This entire area is within a region that is bound predominantly by the 124-m (407-ft) contour interval to the west and east and the 122-m (400-ft) contour interval due east of the BC Cribs area (i.e., flat water table) (Figure 2-2). The water table surface in this area is very flat. Representative sites in the 200 East Area are located in the middle of this very flat area and are relatively close together. The difference in groundwater elevations between these sites is very small, and the groundwater flow direction is difficult to determine. Contaminant plumes in this area suggest that groundwater flow is primarily to the northwest and southeast. The location of the divide between flow is not discernible because the water table is nearly flat primarily due to a zone of high transmissivity (PNNL 2000). The surface of the water table beneath the 200 East Area is currently declining about 0.5 m/yr (1.6 ft/yr) based on water measurements collected between 1998 and 1999.

Groundwater in the 200 West Area occurs primarily in the Ringold Formation. The depth to the water table varies from about 50 m (164 ft) to greater than 100 m (328 ft). Beneath the 216-T-26 Crib, groundwater flow is to the northeast (Figure 2-2). The surface of the water table beneath the 200 East Area is also currently dropping less than 0.5 m/yr (1.6 ft/yr).

2.1.5 Summary of Hydrogeologic Conditions at Representative Sites

A summary of hydrogeologic data (e.g., geologic unit, depth to water) at representative sites is provided in Table 2-1.

2.1.5.1 216-B-46 Crib. The 216-B-46 Crib is located in the northern half of the 200 East Area within an east-west-trending flood channel (DOE-RL 1999). The surface at this site is approximately 191 m (627 ft) amsl. Stratigraphic units at this site (in ascending order) consist of basalt of the Elephant Mountain Member, an undifferentiated Hanford formation/Plio-Pleistocene unit (?), and the Hanford formation sand- and gravel-dominated sequences. All of these facies, with exception of the basalt and the lower section of the undifferentiated Hanford formation/Plio-Pleistocene unit (?), occur within the vadose zone. The stratigraphy at the 216-B-46 Crib is based on data from borehole 299-E33-4 as presented in Wood et al. (2000) (Figure 2-3). Four additional boreholes (299-E33-23, 299-E33-299, 299-E33-310, and 299-E33-11) were drilled adjacent to or in the crib. However, three of the boreholes (299-E33-299, 299-E33-310, and 299-E33-11) were decommissioned. Groundwater beneath

216-B-46 Crib occurs within the undifferentiated Hanford formation/Plio-Pleistocene unit (?), about 69.5 m (228 ft) below ground surface (bgs).

2.1.5.2 216-T-26 Crib. The 216-T-26 Crib is located in a north-south-trending secondary flood channel in the 200 West Area (DOE-RL 1993b). The surface at this site is approximately 205 m (672.6 ft) amsl. Stratigraphic units at this site (in ascending order) consist of basalt of the Elephant Mountain Member; four units of the Ringold Formation (units A, lower mud, E, and upper Ringold); the undifferentiated early Palouse soil/Plio-Pleistocene units; and the Hanford formation sand- and gravel-dominated sequences. Of these units, the Ringold E, upper Ringold, the undifferentiated early Palouse soil/Plio-Pleistocene units, and the Hanford formation are within the vadose zone and are the principal units of interest in this site. The stratigraphy at the 216-T-26 Crib is shown in Figure 2-4 and is based on the geology at boreholes 299-W11-26 and 299-W15-7. Cross sections for these wells are presented Swanson et al. (1999). Two boreholes are present in the immediate vicinity of the crib. Borehole 299-W11-70 is located in the crib; borehole 299-W11-82 is located adjacent to the crib. Groundwater beneath the 216-T-26 Crib occurs within the Ringold Formation unit E about 67.7 m (222 ft) bgs.

2.1.5.3 216-B-5 Reverse Well. The 216-B-5 Reverse well is located in the northwest central section of the 200 East Area within an east-west-trending flood channel (DOE-RL 1999). The surface at this site is approximately 211 m (693 ft) amsl. Stratigraphic units at this site (in ascending order) consist of basalt of the Elephant Mountain Member, two units of the Hanford formation sand- and upper gravel-dominated sequences, and Ringold unit A. Smith (1980) estimates that the Ringold Formation is 27 to 30 m (90 to 100 ft) thick at this location and lies directly on top of basalt. However, Lindsey (1995) suggests that Ringold unit A is only about 5 m (17 ft) thick at this location. The Hanford formation comprises the upper 76 m (250 ft) at the 216-B-5 Reverse Well (DOE-RL 1996). The vadose zone at this location consists of the Hanford formation and a portion of the Ringold Formation unit A. The stratigraphy at the 216-B-5 Reverse Well is based on the geology of borehole 299-E28-23 and interpretations in Smith (1980) (Figure 2-5). Six additional boreholes/wells (299-E28-1, 299-E28-2, 299-E8-3, 299-E28-24, 299-E28-25, and 299-E28-27) provide access to the subsurface in the immediate vicinity of the 216-B-5 Reverse Well. Groundwater beneath the 216-B-5 Reverse Well occurs within the Ringold Formation unit A, about 87.5 m (287 ft) bgs.

2.1.5.4 216-B-7A&B Cribs. The 216-B-7A&B Cribs are located in the northern half of the 200 East Area within an east-west-trending flood channel (DOE-RL 1999). The surface at this site is approximately 199 m (652.7 ft) amsl. Stratigraphic units at this site (in ascending order) consist of basalt of the Elephant Mountain Member, the Hanford formation/Plio-Pleistocene unit (?) gravel, Hanford formation/Plio-Pleistocene (?) silt, and the Hanford formation sand- and gravel-dominated sequences. All of these major facies, with exception of the basalt and the lower section of the Hanford formation/Plio-Pleistocene unit (?), occur within the vadose zone. The stratigraphy at the 216-B-7A&B Cribs is based on data from borehole 299-E33-18 as presented in Wood et al. (2000) (Figure 2-6). Four boreholes (299-E33-58, 299-E33-59, 299-E33-60, and 299-E33-75) provide access to the subsurface in the immediate vicinity of the 216-B-7A&B Cribs. Groundwater beneath the 216-B-7A&B Cribs occurs within the Hanford formation/Plio-Pleistocene unit (?) gravel, about 76.8 m (252 ft) bgs.

2.1.5.5 216-B-38 Trench. The 216-B-38 Trench is located in the northern half of the 200 East Area in an east-west-trending flood channel. Maps of the location indicate that the surface is approximately 202.5 m (664.4 ft) amsl. Stratigraphic units at this site (in ascending order) consist of basalt of the Elephant Mountain Member, an undifferentiated Hanford formation/Plio-Pleistocene unit (?), and the Hanford formation sand- and gravel-dominated sequences. All of these facies, with exception of the basalt and the lower section of the undifferentiated Hanford formation/Plio-Pleistocene unit (?), occur within the vadose zone. The stratigraphy at the 216-B-38 Trench is based on data from borehole 299-E33-8 as presented in Wood et al. (2000) (Figure 2-7). Two boreholes (299-E33-289 and 299-E33-290) provide access to the subsurface in the immediate vicinity of the 216-B-38 Trench. Groundwater beneath the 216-B-38 Trench occurs about 78.4 m (257 ft) bgs.

2.2 WASTE SITE DESCRIPTION AND HISTORY

The 200-TW-1 Scavenged Waste Group and 200-TW-2 Tank Waste Group OUs consist of 64 waste sites and unplanned releases. Seventeen waste sites are located in the north-central portion of the 200 West Area. Twenty-four waste sites are located in the northwest section of the 200 East Area. The remaining 23 waste sites are located about 400 m (1,300 ft) south of the 200 East Area fence. All 200-TW-1 and 200-TW-2 waste sites are located within the 200 Area exclusive land-use boundary as defined in the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE 1999a) (Figure 2-8). Figures 2-9, 2-10, and 2-11 depict the locations of the waste sites. The 200-TW-1 OU includes 35 CPP waste sites and 1 UPR waste site that received mostly fission product-depleted (i.e., scavenged) liquid waste. The 200-TW-2 OU contains 27 RPP waste sites and 1 UPR waste site that received first- and second-cycle bismuth/phosphate process waste or tank waste. Summary information on 200-TW-1 and 200-TW-2 OU waste sites is presented Tables 2-2 and 2-3, respectively.

Most of the waste discharged to the soil column in these OUs was generated at the T, B, and U Plants between 1944 to 1957. The locations of these plants are illustrated in Figure 2-12.

2.2.1 Plant History

The T and B Plants were constructed in 1944. The T and B Plants are composed of several buildings, including the 221-T/B Buildings (also known as the "canyon buildings" due to their shape and appearance) and the 224-T/B Buildings (also known as the concentration buildings due to the operational procedures performed there). The T and B Plants received and processed irradiated fuel rods from the 100 Area reactors. The fuel rods were subject to several chemical separation and purification steps to produce the desired plutonium product. The plutonium separation and purification operations ceased in 1956 at T Plant and in 1952 at B Plant (DOE-RL 1993b, 1993d).

The U Plant, constructed in 1944, was based on the design of the T and B Plants and was initially used to train personnel for the uranium/plutonium separation and purification operations conducted in T and B Plants. Reportedly, only water was used for training purposes and no waste streams were generated in this early training operation. In 1951, U Plant was modified to

facilitate the URP processes. This mission, conducted from 1952 to 1958, served two purposes: (1) to recover unprocessed uranium to be reirradiated and processed into plutonium, and (2) to reduce the volume of waste generated at T and B Plants. A secondary operation was later added to the URP processes in U Plant to "scavenge" or precipitate out of solution long-lived fission products in the settling process before discharge (DOE-RL 1992).

Liquid wastes generated at T, B, and U Plants were routed to several underground storage tanks within the T, TX, TY, B, BX, and BY Tank Farms through a series of collection and transfer tanks, diversion boxes, vaults, and piping. This allowed the heavier constituents to settle out from solution and form sludge and was known as "cascading." The remaining liquid supernatants were discharged to the soil column in cribs, drains, trenches, and injection/reverse wells (Waste Information Data System [WIDS]).

Cribs and drains were designed to percolate wastewater into the ground without exposure to the open air. French drains were usually constructed of steel or concrete pipe and were either open or filled with gravel. Cribs were shallow excavations that were either backfilled with permeable material or held open by wooden structures. Cribs usually had an additional layer of an impermeable substance, which allowed the water to flow directly into the backfilled material, or covered space, and percolate into the vadose zone soils. Cribs and drains typically received low-level radioactive waste for disposal. Most were designed to receive liquid until a specific retention volume or radionuclide capacity was met (DOE-RL 1993b, 1993d).

Trenches are shallow, long, narrow, and unlined excavations. Trenches received limited quantities of sludge and/or liquid wastes. Often, trenches were located in close proximity to other trenches. Some have been backfilled and marked as a single group of trenches regardless of whether they contained the same type of waste (DOE-RL 1993a, 1993b).

Injection/reverse wells were usually encased holes that were drilled with the lower end perforated or open to allow liquid to seep to the vadose zone. These units injected wastewater into the vadose soil at depths greater than the other disposal sites. Injection wells were generally constructed of steel or concrete pipe and were either open or filled with gravel. Injection wells were used for the disposal of "early" liquid wastes from T and B Plants. However, liquid wastes were rerouted to cribs and trenches from the injection wells as the wells were filled (DOE-RL 1993b, 1993d).

2.2.2 Process Information

Several processes occurred at T, B, and U Plants that generated waste streams (Figures 2-13 and 2-14). The T, B, and U Plant processes that are the primary sources of waste disposed to the 200-TW-1 and 200-TW-2 OU waste sites include the following:

- Bismuth-Phosphate Separation Process generated 221-T or B Building waste including dissolved cladding, metal waste, and first- and second-cycle waste streams.

- Lanthanum-Fluoride Purification Process generated 224-T or B Building waste streams including purification waste or lanthanum/fluoride waste streams.

- URP Process generated U Plant waste including tributyl phosphate (TBP) waste or column waste, solvent recovery waste, acid recovery waste, off-gas condensates, and uranium trioxide or powdered waste streams.

- Scavenging (Fission Product Precipitation) Process generated the scavenged and in-tank scavenged waste, including the fission products waste streams.

- Plant Shut-Down and Equipment Decontamination Process generated dilute washings of the waste streams mentioned above.

2.2.2.1 Bismuth-Phosphate Separation Process. Irradiated uranium slugs rich with plutonium were transferred from the 100 Area to the 200 North Area via shielded rail car for a 45- to 60-day period of intermediate storage in large tanks containing water. After the necessary period of storage, the slugs were sent via rail car to the T and B-221 Buildings (HEW 1945). The rods came with an aluminum/aluminum-silicate cladding as a protective jacket. The first step of separation was to dissolve this cladding using a sodium hydroxide solution; sodium nitrate and mercury were added to prevent the generation of hydrogen gas and assist in dissolving the aluminum cladding. The liquid effluent was composed of the sodium hydroxide solution and the dissolved aluminate-sodium nitrate/nitrite. This solution became known as the "dissolved cladding" waste stream (GE 1944). This waste stream was sent to tanks 241-T-104, 105, 106, 109, 110, and 111, and tanks 241-B-110, 111, 112, 201, 202, 203, and 204. This waste stream was often combined with first-cycle waste. Waste sites 216-T-14 to 216-T-17, 216-T-21 to 216-T-25, and 216-B-35 to 216-B-41 are specifically referenced to contain waste generated from this process (DOE-RL 1993b, 1993d). However, it is likely that all of the 200-TW-2 OU waste sites may contain some of this waste through drainage or overflow from canyon building cells 5 and 6 (GE 1944).

After the cladding was removed, the fuel rod was rinsed with water and dissolved into a concentrated solution of nitric acid known as the "dissolver solution." Plutonium, uranium, and fission products including cobalt-60, strontium-90, and cesium-137 isotopes were present in this solution (GE 1944).

The next step of the bismuth-phosphate process involved the separation of the fission products and uranium ions from the plutonium ions. Sodium nitrite solution was added to a batch of dissolver solution to ensure that the plutonium ion would have a valence of 3+ or 4+. Bismuth nitrate, phosphoric acid, and sulfuric acid were added to this solution causing the plutonium and approximately 10% of the fission products to precipitate out of solution as a bismuth phosphate complex, a white powder (GE 1944).

Once the precipitant was separated from the supernatant, the supernatant was sent to the 241-T, TX, TY, and 241-B, BX, and BY Tank Farms. This waste stream was known as the metal wastes stream and contained approximately 100% of the uranium and 90% of the fission products. This waste was so concentrated with radionuclides that storage in the tank farms was the only acceptable waste disposal solution (GE 1944). None of the waste sites in the 200-TW-1 or 200-TW-2 OUs are reported to have received metal waste.

The plutonium/bismuth phosphate precipitant was washed with water; washings were disposed of as first-cycle waste. The precipitant was then redissolved in a concentrated solution of nitric and phosphoric acids, recreating the plutonium 4+ ion in solution. A sodium dichromate solution was added to convert and stabilize the plutonium 4+ ion to a 6+ ion by an oxidation reaction. The plutonium was in the form of a plutonium oxide complex, which was insoluble during the bismuth/phosphate precipitation (GE 1944).

Bismuth nitrate, phosphoric acid, and sodium metabismuthate were added to the solution. The plutonium 6+ ion remained in solution and a bismuth phosphate precipitate again formed, containing more of the residual fission product impurities. The precipitant containing the fission product impurities was redissolved and disposed of as first-cycle waste (GE 1944).

The plutonium 6+ ion-rich solution was then combined with ammonium fluosilicate, ferrous ammonium sulfate, bismuth oxynitrate, hydrogen peroxide, and phosphoric acid. Again, the white plutonium/bismuth phosphate precipitant formed, separating more of the fission products (remaining in solution) from the desired plutonium. This liquid was also disposed of as first-cycle waste (GE 1944).

First-cycle waste contained approximately 10% of the fission products. First-cycle waste was routed for disposal through tanks at the T, TX, TY, B, BX, and BY Tank Farms. The 200-TW-2 OU waste sites 216-T-14 to 216-T-17, 216-T-21 to 216-T-25, and 216-B-35 to 216-B-41 are reported to contain waste generated from this process. However, it is likely that all of the 200-TW-2 OU waste sites may contain some of this waste through drainage or overflow from canyon building cells 5 and 6 (GE 1944, WHC 1991).

This entire precipitation cycle was repeated. The resulting waste stream was known as the second-cycle waste stream. The second-cycle waste contained approximately 0.1% of the fission products and was routed for disposal through tanks 241-T-105, 241-T-110, 241-T-111, 241-T-112, and 241-T-201 to 241-T-204 and 241-B-110, 241-B-111, 241-B-112, and 241-B-201 to 241-B-204. Waste sites 216-T-3, 216-T-5, 216-T-6, 216-T-7, and 216-T-32 and 216-B-5, 216-B-7A&B, 216-B-8, and 216-B-9 are reported to contain waste generated from this process. However, all of the 200-TW-2 OU waste sites likely contain some of this waste through drainage or overflow from canyon building cells 5 and 6. The solution resulting from the second precipitation cycle was a dilute plutonium nitrate supernatant that was sent to the 224-T and B Buildings for further purification and volume reduction (GE 1944, WHC 1991).

2.2.2.2 Lanthanum-Fluoride Purification Process. The lanthanum/fluoride process was a second part of the bismuth-phosphate separation process. The lanthanum/fluoride process further purified the dilute solution created in the last step of the bismuth/phosphate process. The dilute plutonium nitrate supernatant was first oxidized with sodium metabismuthate. Phosphoric acid was added to precipitate out impurities. The waste precipitant was redissolved in nitric acid and disposed of as waste from the 224-T or B Buildings. The plutonium-containing supernatant was then treated with oxalic and hydrofluoric acids and lanthanum salt. As a result, lanthanum fluoride and plutonium fluorides were co-precipitated. The supernatant was discharged as waste

from the 224-T or B Buildings. These solids were washed with water. The washings were discharged as 224-T or B waste (GE 1944; WHC 1991; DOE-RL 1993b, 1993d).

The lanthanum and plutonium fluoride solids were then converted to hydroxides by the addition of a hot potassium hydroxide solution. The hydroxides were washed with water (washings were again discharged as 224-T or B waste), dissolved in nitric acid, and heated to form a concentrated plutonium nitrate solution. This solution was sent to the isolation building (231-T or B) for further purification treatments and evaporation. A concentrated plutonium nitrate paste was the final product. For every batch or 760 L (200 gal) of dilute plutonium, unpurified solution entering 224-T Building, an estimated 30 L (8 gal) of purified concentrated weapons-grade plutonium was produced (GE 1944).

The waste generated by the lanthanum fluoride purification and volume reduction process was routed initially to the 241-B-361 and 241-T-361 settling tanks, with the overflow proceeding to the 216-B-5 and 216-T-3 injection wells for discharge. When the 241-B-361 and 241-T-361 collection tanks and the B and T injection wells reached capacity, the 224-T or B waste was then diverted to single-shell tanks (SSTs) 241-B-201 through 241-B-204 and 241-T-201 through 241-T-204. This allowed the solids in the waste to settle before discharging the liquid effluents to the 216-B-7A&B, 216-T-6, 216-T-7, and 216-T-32 Cribs (WIDS).

2.2.2.3 Uranium Recovery Process. From 1952 to 1958, the URP was implemented at the U Plant to recover the spent uranium from the metal waste and first-cycle waste streams generated in the T and B Plants for reuse in weapons-grade plutonium production. The URP was performed in the following three phases (GE 1951):

- Removal of bismuth/phosphate waste (metal waste, first-cycle supernatants, and cell 5 and 6 drainage) from underground storage and preparation of the sludge/slurry solution
- Separation of the uranium from plutonium, fission products, and chemicals
- Conversion of the uranium into uranium trioxide powder.

The metal waste and first-cycle waste stored in the T and B Tank Farms was sent to U Plant via a network of underground pipes, tanks, and diversion boxes where it was deposited into cascading underground storage tanks. The uranium-rich bismuth phosphate waste streams often turned into a sludge/supernatant combination because of the basic pH level of the waste solution. (pH was usually adjusted and maintained at 10.5 due to the corrosiveness of the waste stored in the tanks.) The sludge was dissolved into a liquid solution to be pumped from the tanks into the 221-U Building. An aqueous solution was jetted at a high pressure into the sludge to dissolve it into a slurry solution. Water and/or sodium carbonate, ammonium bicarbonate, or sodium bicarbonate solutions were used as alternatives to enhance solubility. The supernatant was recycled and reused in the dissolution process of the sludge.

The sludge/supernatant slurry was pumped to an accumulation tank. The sludge settled and was transferred to an agitated dissolver tank, while the supernatant was recycled. To prepare the separation feed, a large quantity of nitric acid was added to the sludge. The nitric acid served

two purposes. First, it dissolved the uranium-rich sludge into an aqueous phase. Second, it acted as a "salting agent" reducing the solubility of the uranyl nitrate in the aqueous phase and increasing its solubility during the first separation via extraction column. The pH was adjusted in the resulting solution that was concentrated by evaporation. This concentrated feed solution was then sent to the first-cycle extraction column. The off-gasses were collected, condensed, and disposed of in cribs, ditches, and trenches near U Plant; these sites are not included in either the 200-TW-1 or 200-TW-2 OUs.

The uranium-rich feed entered the extraction column at mid-point. A countercurrent flow of TBP dissolved in a hydrocarbon solution (usually kerosene or paraffin) extracted the uranium from the feed solution into the TBP/organic solution. The fission products, plutonium, and other inorganic chemicals from the bismuth-phosphate process remained in the aqueous feed solution. A "scrub solution" composed of nitric and sulfamic acids along with ferrous ammonium sulfate was also introduced at the top of the column. The scrub solution was used to scrub the fission products from the extraction column and ensure that the plutonium remained in solution as a 3^+ ion. The aqueous waste steam was sent to a waste treatment collection tank for further processing. This separation/extraction was a continuous flow process.

The TBP/organic solution rich with uranium left the first extraction column and continued to a second extraction column. At this column, the TBP/organic solution entered the bottom of the column and was met by a countercurrent flow of water. As the organic solution did not contain a "salting agent" to bind the uranium in solution, the water extracted the uranium from the organic solution into an aqueous phase. The waste organic solution was sent to the solvent recovery operation in U Plant, while the aqueous solution containing the uranium was sent to the uranium trioxide process in U Plant.

The solvent recovery operation at U Plant used a scrubber column and a sodium sulfate solution to remove any residual fission products, plutonium, and/or inorganic salts including nitrates from the organic solvent. The purified organic/TBP solvent was recycled, and the scrubber solution containing impurities was sent to the waste collection tank in the 241-WR/ER vaults and later scavenged and sent to cribs and trenches, including the 200-TW-1 OU waste sites 216-B-20 to 216-B-34, 216-B-42 to 216-B-49, 216-B-51, and 216-B-52, and 216-T-18 and 216-T-26 via underground pipelines and diversion boxes (Curren 1972, WHC 1990).

The aqueous phase containing the uranium was combined with the concentrated uranyl nitrate hexahydrate solution from the reduction and oxidation (REDOX) operations and sent to the uranium trioxide plant for the conversion of the uranyl nitrate solution into uranium trioxide powder. The solutions passed through two evaporators that evaporated the water/nitric aqueous component and concentrated the solution with uranyl nitrate. The off gasses were collected and sent to a fractionation operation in U Plant where the nitric acid was recovered and reused in the dissolver tank for feed preparation or routed to cribs, ditches, and trenches near the U Plant for disposal (Curren 1972).

The concentrated uranyl nitrate solution was sent to calcination vessels. These vessels were electrically heated and contained agitators or stirring mechanisms. The vessels were heated for 5 hours. This allowed the uranyl nitrate solution to maintain a temperature of 400°F. The

off-gasses were again collected and sent to a fractionation operation where nitric acid was recovered and reused in the dissolver tank for feed preparation and/or routed to cribs, ditches, and trenches near U Plant for disposal. Once thermo-decomposition was completed, uranium trioxide powder was formed. The powder was removed from the vessels, packaged, and shipped offsite to Oak Ridge, Tennessee, where it was converted to uranium metal. The metal was returned to the 300 Area to be reincorporated into the uranium fuel rod production (GE 1951).

The aqueous waste streams generated in this TBP/URP process from each of the extraction columns were sent to an aqueous waste collection tank. The waste was pooled until an optimal volume was received and a sample was obtained. Once the waste collection tank reached optimal volume (usually 45,425 L [12,000 gal]), it was condensed and then sent back to the feed accumulation tank for reprocessing or routed to the neutralization tank. In the neutralization tank, the waste was combined with an equal volume of 50% caustic soda (sodium hydroxide) to obtain a pH of 9.5. As a measurable quantity of ammonia was generated by neutralization, additional amounts of 50% caustic soda (sodium hydroxide) were added to raise the pH to 11.5 (GE 1951).

Waste from the neutralization tank was sent to a concentrator in the 221-U Building where the volume of the aqueous waste was reduced through evaporation. The concentrate (or remaining sludge/slurry solution) was pumped back to underground storage tanks, including the 241-B, BX, and BY and 241 T, TX, and TY Tank Farms. The recovered condensate and other recovered condensates (from off-gasses generated during the feed preparation, calcination, solvent recovery, and nitric acid recovery operations) were routed to cribs, trenches, and ditches for disposal via diversion vaults (including the waste sites within the 200-TW-1 OU). Cooling water, steam condensates, and nonradioactive/nonhazardous wastes were routed to U Plant trenches and ditches for disposal into the soil column (GE 1951).

2.2.2.4 Scavenging Process. In 1953, tests to further treat the metal waste and first-cycle waste streams generated at T and B Plants during the bismuth-phosphate campaign proved successful. The "scavenging" process separated the long-lived fission products, including strontium and cesium, from the waste solutions by precipitation. This process served two purposes: (1) it reduced the volume of waste containing long-lived fission products previously stored within the tank farms, and (2) it allowed the remaining waste liquid effluents (no longer containing the long-lived fission products) to be discharged to the soil column. Waste liquid effluents from the test batches were sent to the 216-T-18 Crib for disposal into the soil column (Agnew et al. 1997, Curren 1972, GE 1958).

From 1954 to 1958, the scavenging process was conducted at U Plant after the URP operations. The order of operations was often modified throughout the duration of the scavenging process. Parameters such as pH, addition of other metals to enhance precipitation, and soil retention properties were also continually changing. After URP processing, TBP column wastes were sent to a neutralization tank at U Plant where the pH was adjusted to 9 ± 1. Chemicals used to scavenge fission products included potassium and sodium derivatives of the metal/ferrocyanide complex ion. The most notable and widely used metals (used to assist precipitation) were iron, nickel, and cobalt. Calcium nitrate and/or strontium nitrate were often added to enhance the precipitation of the radioactive strontium-90. Phosphate ions were also added to aid the soil

retention of strontium-90. Once the TBP waste had been scavenged, the waste was returned to the B, BX, BY, T, TX, and TY Tank Farms to allow the solids (containing the fission products and scavenging chemicals) to settle for approximately 1 week. The waste liquid effluent was sampled and analyzed from the tanks at various depths. The waste liquid effluent was sent to cribs and/or trenches if the amounts of cesium-137 and strontium-90 were within limits; otherwise, the liquid waste was rerouted to other nearby tanks and settling continued. In extreme cases, rescavenging occurred "in tank" to further precipitate fission products out of solution. The cribs and trenches receiving the scavenged TBP waste include 200-TW-1 OU waste sites 216-B-14 to 216-B-34, 216-B-42 to 216-B-49, 216-B-51, 216-B-52, and 216-T-26 (GE 1951, DOE-RL 1992, WIDS, Borsheim and Simpson 1991, GE 1958).

In 1955, "in tank" or "in tank farm" scavenging operations also began. "In tank" scavenging was conducted to process the TBP waste previously generated in U Plant before the implementation of the scavenging operation that had been returned to the 241- B, BX, BY, T, TX, and TY Tank Farms. The TBP wastes were transferred from the tanks to vaults, including the 244-CR Vault, near the Plutonium-Uranium Extraction (PUREX) Plant where the TBP waste was scavenged and sent back to the original tank farms. The same chemicals were used in the "in tank" scavenging as were used in the U Plant. Often, rescavenging was performed in batches from tanks in the T, TX, TY, B, BX, and BY Tank Farms when the liquid effluents did not meet cribbing or trenching limits. The cribs and trenches that received "in tank" or "in tank farm" scavenged and/or rescavenged TBP waste include 200-TW-1 OU waste sites 216-B-17, 216-B-19 to 216-B-23, 216-B-28, 216-B-30 to 216-B-34, and 216-B-52 (Curren 1972). The "in tank" scavenging operations ended in 1957, and the last of the liquid effluents were discharged in 1958 (GE 1954a, 1954b, 1955, 1956, 1958).

Post-T and B Plant sources of waste disposed in the 200-TW-1 and 200-TW-2 OU waste sites include the following (DOE-RL 1993b, 1993d):

- Decontamination and equipment refurbishment, including ammonium silicafluoride tests
- Pacific Northwest National Laboratory (PNNL) waste
- Bismuth-phosphate waste treatment experiments
- Dissolved coating wastes from PUREX Plant.

The facilities of T and B Plants were used for several different purposes after the bismuth/phosphate campaign ended. Additional waste streams that may have contributed to either 200-TW-1 or 200-TW-2 OU waste sites include the following:

- 221-T, 1957 to 1991: The 221-T Building was converted to a decontamination and equipment refurbishment facility. The facility provided services in radioactive decontamination, reclamation, and decommissioning of process equipment. Radioactive wastes from these decontamination activities were discharged to double-shell tanks. Nonradioactive waste streams including condensate, cooling water, and heating coil water were discharged to the chemical sewer. Usually steam was used as the primary scrubbing solution for the early decontamination and equipment refurbishment purposes. Tests were also performed using ammonium silicafluoride, chromic acid, glycerin, and various citrate

and oxalate compounds along, with many industrial caustics including borax and calgon, as different dissolver solutions. The waste from early decontamination operations was discharged to the soil at disposal sites 216-T-9 to 216-T-11, 216-T-13, and 216-T-28 (sites not in either OU). However, there is a possibility that the 200-TW-2 OU waste sites received small amounts. During the bismuth/phosphate campaign, decontamination efforts were performed on a routine basis as housekeeping measures to wash/rinse the equipment and cell walls within the building.

- 221-T, 1959 to 1969: 300 Area laboratory wastes were shipped via truck from the 340 Building to the 200 West Area and combined with the 221-T Building and 2706-T Building waste streams. These were disposed of via tanks into the 216-T-27, 216-T-28 (these two cribs are not in either OU), and possibly the 216-T-26 Cribs/Trenches (WIDS). Laboratory waste streams generated in the 300 Area could contain aluminum canning process wastes including bronze, tin, silica, and aluminum. Bismuth/phosphate, URP, REDOX (ion exchange), and PUREX separation processes were also tested in the 300 Area. However, it was noted that these "bench-scale" experiments contained mainly inorganic chemicals and very small amounts of radionuclides during the 216-T-26, 216-T-27, and 216-T-28 Cribs active disposal period.

- 221-B, 1950 to 1966: 221-B was used to begin waste treatment methods including scavenging operational experiments. Chemicals used for this experimental work included metals, acids, bases, and complexing agents, including ferro- and ferricyanide. The amounts of this specific type of waste were extremely small, and few records were kept regarding the disposal of this waste. Most of the waste treatment experiments are believed to have been performed on "tank waste" and very few were successful (other than the scavenging process); most of the waste was disposed into nearby tanks. From 1963 to 1966, the first phase of the Waste Fractionalization Project was completed in the 221-B Building. This first phase included the recovery of strontium, cerium, and rare-earth metals using an acid oxalate-precipitation process. Once the waste had been fractionalized by centrifuge, it was pumped via underground pipelines to the Semiworks for further processing.

- 241-B and 241-BY Tank Farms, 1956 to 1988: Dissolved coating or cladding waste from PUREX was often sent to the 241-B and/or 241-BY Tank Farms. This waste was produced by dissolving the aluminum/zirconium "can" around the plutonium-enriched uranium sludge with sodium hydroxide. This PUREX chemical process was the same chemical process as was used during the bismuth-phosphate campaign. Thus, the intermixing of these two waste streams proved to be inconsequential. It is unclear if any PUREX cladding waste was released with bismuth-phosphate cladding waste when it was mixed with first-cycle waste and released to the 216-B-5, 216-B-8, and 216-B-35 to 216-B-41 waste sites. However, all chemical constituents are the same.

2.2.3 Representative Sites

The concept of using analogous sites to reduce the amount of site characterization and evaluation required to support remedial action decision making is discussed in the Implementation Plan (DOE-RL 1999). The use of this approach relies on first grouping sites with similar location,

geology, waste site history, and contaminants, and then choosing one or more representative sites for comprehensive field investigations, including sampling. Findings from site investigations at representative sites are extended to apply to other sites in the waste group that were not characterized. Sites for which field data have not been collected are assumed to have similar chemical characteristics to the sites that were characterized. Confirmatory investigations of limited scope can be performed at the sites not selected as representative sites, rather than full characterization efforts.

Data from representative sites are used to evaluate remedial alternatives and to select one (or more) to apply for the entire waste group. Confirmatory sampling of the analogous sites after remedy selection may be required and is built into the remedial design planning to demonstrate that analogous conditions exist. Although a degree of uncertainty exists in employing the analogous site concept, substantial benefit is realized in the early selection of a remedy that allows early cleanup action to be performed. As defined in the Implementation Plan (DOE-RL 1999), five representative sites were identified for the 200-TW-1 and 200-TW-2 OUs. Representative sites in the 200-TW-1 OU include the 216-B-46 Crib and 216-T-26 Crib. Representative sites in the 200-TW-2 OU include the 216-B-5 Injection/Reverse Well, 216-B-7A&B Cribs, and 216-B-38 Trench.

The 216-B-46 Crib was selected as a representative site because of its significant radionuclide inventory and the current level of characterization associated with the 216-BY Cribs, inclusive of the 216-B-46 Crib. Results of the investigation activities at the BY Cribs are presented in the *Phase I Remedial Investigation Report for 200-BP-1 Operable Unit* (DOE-RL 1993c). The 216-T 26 Crib was selected because of its high contaminant inventory. The 216-B-38 Trench was selected because it received a high inventory of fission products. The 216-B-7A&B Crib system is considered to be a "worst-case" site because it received the highest combined quantities of plutonium, cesium, and strontium. The 216-B-5 Reverse Well is considered a second choice "worst-case" site because of its high radiological inventory, current impact on the aquifer, and current level of characterization. Details of the investigation activities for this site are presented in Smith (1980).

During the process of evaluating representative sites, consideration was also given to including a BC Cribs area waste site in the initial phase of characterization for the OU. This consideration was deemed necessary because of the lack of quality geologic, physical property, and chemical data in the vicinity of the BC Cribs. The BC Cribs are located about 150 m (490 ft) south of the 200 East Area perimeter fence and consist mainly of specific retention waste sites. The contaminant inventories received at these waste sites are comparable to other OU waste sites; however, effluent volumes discharged at the BC Cribs do not exceed estimated soil pore volume beneath the waste sites. These data suggest that significant impact to groundwater is not expected. Recent results from the logging of 18 boreholes in the BC Cribs area with the radionuclide logging system support this conclusion. For example, the 216-B-14 Crib received a waste volume equal to about 50% of the estimated soil pore volume in the vadose zone beneath this crib. The radionuclide logging system log profile, which provides an indicator of contaminant fate, shows that cesium-137 contamination extends only to a depth of 27 m (90 ft) and detectable cobalt-60 extends to a depth of 70 m (231 ft). The vadose zone thickness (104 m [340 ft]) in the vicinity of the cribs and the limited effluent volume discharged are the two main

mitigating factors with regard to impact on groundwater. Groundwater monitoring wells currently located in the BC Cribs area do not indicate groundwater contamination; however, the monitoring network is limited in this area. While the information concerning the groundwater quality in the BC Cribs area is limited, this is outside the scope of this work plan.

The quality of geologic and physical property data for the crib area are addressed by evaluating existing information collected from the US Ecology Low-Level Radioactive Waste Disposal Facility and the proposed Immobilized Low-Activity Waste Site. These sites are located less than 0.8 km (0.5 mi) west and northeast of the BC Cribs, respectively. Information from these sites includes the following types of data: geologic logs, cross sections, grain size distribution, particle density, moisture content, matric potential, porosity, and saturated and unsaturated hydraulic conductivity. These data are presented in Reidel et al. (1998), US Ecology (1999), Khaleel (1999), and DOE-RL (1993a). Based on the existing information available, the existing data from the BC Cribs area and vicinity are considered sufficient to support RI/FS decision making. Current resources would be better used by evaluating conditions at the BC Cribs during later phases of sampling and analysis (i.e., confirmation and verification sampling) as described in the Implementation Plan (DOE-RL 1999).

The following sections describe the representative sites in detail. Information was obtained from the WIDS database and WIDS historical files unless otherwise noted.

2.2.3.1 216-B-46 Crib. The 216-B-46 Crib is an inactive liquid waste disposal site located north of the BY Tank Farm and west of Baltimore Avenue; the crib is situated north of the 216-B-45 Crib and south of the 216-B-47 Crib.

From September to December 1955, the crib received approximately 6,700,000 L (1,800,000 gal) of URP bismuth/phosphate waste that had also been scavenged (fission products precipitated out). Once the waste was processed at U Plant, it was sent to the 241-BY Tank to allow settling of the sludge. The remaining waste liquid effluent was discharged to the crib.

The 216-B-46 Crib is constructed of four large-diameter vertical concrete pipes, set below grade in a square pattern with the centers spaced 4.6 m (15 ft) apart in a 9- by 9- by 4.6-m (30- by 30- by 15-ft) deep excavation (DOE-RL 1991) (Figure 2-15). The crib was fed by a central pipe that branches into a chevron pattern to feed each vertical pipe. The vertical pipes are 1.2 m (4 ft) in diameter and 1.2 m (4 ft) long, placed 2 m (7 ft) below grade and set on a 1.5-m (5-ft)-thick bed of gravel (Stenner et al. 1988). Maxfield (1979) reports that the feed pipe to the crib was valved out when the specific retention capacity of the soil under the crib was reached. The *Remedial Investigation/Feasibility Study Work Plan for the 200-BP-1 Operable Unit, Hanford Site, Richland, Washington* (DOE-RL 1990) states that the crib received volumes beyond its specific retention capacity. Groundwater below the crib has been impacted (WIDS).

Inorganic compounds in the liquids disposed to the crib included ferrocyanide, nitrate, phosphate, sodium, and sulfate-based compounds. Radionuclides contained within the waste stream sent to these cribs include cesium-137, strontium-90, ruthenium-106, plutonium, and uranium isotopes (Maxfield 1979, WHC 1991, Brown et al. 1990). The crib also contains organic constituents such as mono, di, and TBPs.

In 1991, the site was interim stabilized with 0.6 m (2 ft) of clean soil. Three characterization boreholes were drilled and geophysically logged; soil samples were collected and analyzed. Results of this investigation are documented in the Phase 1 200-BP-1 OU RI (DOE-RL 1993c).

2.2.3.2 216-T-26 Crib. The 216-T-26 Crib is an inactive liquid waste disposal site located 61 m (200 ft) north of 22nd Street and east of the 241-TY Tank Farm (WHC 1991). It is the northernmost crib of the 216-T-26, 216-T-27, and 216-T-28 Crib series. The 216-T-26 through 216-T-28 Cribs are currently fenced within a light chain barricade and underground contamination warning placards.

Between August 1955 and November 1956, the 216-T-26 Crib received approximately 1.2×10^7 L (3.2×10^6 gal) of liquid waste. This waste originated at T Plant as metal waste and first-cycle waste that had been recovered through the URP and scavenged at U Plant. The waste was then transferred back to the TY Tank Farm to allow the sludge to settle; the liquid effluent was discharged to the crib (WHC 1992, Stenner et al. 1988).

This crib has the same basic construction as the 216-B-46 Crib (Figure 2-15). A 36-cm (14-in.) steel inlet pipe reduces to a 25-cm (10-in.) pipe located approximately 3 m (9 ft) below grade. The smaller section of pipe branches into four 20-cm (8-in.) steel pipes that feed the large-diameter vertical concrete pipes, which are approximately 1.2 m (4 ft) long and 1.2 m (4 ft) in diameter. The piping lies within in a 9- by 9- by 4.6-m (30- by 30- by 15-ft)-deep excavation. The base of the crib was placed at 4.6 m (15 ft) bgs, and the excavation was filled with approximately 2.4 m (8 ft) of gravel followed by approximately 2.4 m (8 ft) of earth backfill.

This unit was deactivated in 1956 by blanking the line leading to the 216-T-26 and 216-T-28 Cribs between the 241-TY Tank Farm and the roadway. In 1975, stabilization activities were performed for the 216-T-26, 216-T-27, and 216-T-28 Cribs. This remedial action consisted of scraping off the top 15 cm (6 in.) of soil and replacing the excavated material with clean fill to the original grade (WHC 1991). The contaminated soil was placed in the 200 West Area dry waste burial grounds. This unit was surface stabilized again in May 1990 (WIDS).

Waste disposed of at this unit includes ferrocyanide complexes, fluoride, nitrate, nitrite, phosphate, sodium, sodium aluminate, sodium hydroxide, sodium silicate, sulfate, cesium-137, ruthenium-106, strontium-90, gross amounts of plutonium, and uranium.

2.2.3.3 216-B-5 Injection/Reverse Well. The 216-B-5 Injection/Reverse Well is an inactive waste management unit that was constructed in 1944. It is located about 300 m (1,000 ft) northeast of the 221-Building and east of Baltimore Road. From April 1945 until September 1946, it received overflow waste from the 241-B-361 Settling Tank, which received lanthanum/fluoride process waste from the 224-B Concentration Facility and bismuth/phosphate process drainage from cells 5 and 6 in the 221-B Building. Between September 1946 and October 1947, drainage and other liquid waste from cells 5 and 6 were directly injected into the well (WHC 1991, Brown et al. 1990). Approximately 31,000,000 L (8,100,000 gal) of liquid were discharged to the 216-B-5 Injection/Reverse Well, containing an estimated 4,275 g of plutonium and 3,800 Ci of beta-gamma activity (Brown and Ruppert 1950).

The 216-B-5 Injection/Reverse Well consists of four casing strings: a 40-cm (16-in.) casing to 4 m (13 ft), a 30-cm (12-in.) casing to 31 m (102 ft), a 25-cm (10-in.) casing to 74 m (243 ft), and a 20-cm (8-in.) casing to 92 m (302 ft). The final casing string is perforated from a depth of 74 to 92 m (243 to 302 ft) (Brown and Ruppert 1950). Total depth of the reverse well is 92 m (302 ft). The well penetrated about 3 m (10 ft) into the aquifer in 1947. The well received effluent from the 241-B-361 Settling Tank through a 5-cm (2-in.) stainless steel inlet pipe located 4 m (13 ft) below grade.

In 1947, the water table elevation in well E33-18 demonstrated that the reverse well penetrated about 3 m (10 ft) into the groundwater and that radioactive waste had been discharged into the groundwater. The 216-B-5 Reverse Well was deactivated by blanking the pipeline inlet to the well and cell 5 and 6 wastes were rerouted to the 216-B-7A and 216-B-7B Cribs (Maxfield 1979).

A surface contamination area around the well was interim stabilized in 1994 with 46 to 61 cm (18 to 24 in.) of crushed concrete from the demolished 190-B Facility. The area was surveyed and downposted to an underground radioactive material area.

2.2.3.4 216-B-7A&B Cribs. The 216-B-7A&B Cribs consist of two inactive wooden cribs, approximately 6 m (20 ft) apart, located 30 m (100 ft) north of the 241-B-Tank Farm. The cribs operated from September 1946 to May 1967 and received a total volume of 43,600,000 L (11,500,000 gal) of waste (Maxfield 1979). From October 1946 to August 1948, these cribs received overflow from SST 241-B-201 (a settling tank). The waste included second-cycle waste from the 221-B Building, lanthanum/fluoride process waste from the 224-B Building, and cell drainage and other liquid waste (low salt, alkaline, radioactive liquid) via cells 5 and 6 in the 221-B Building. Tank 241-B-201 was taken out of service in October 1948 because it was nearly filled with sludge from 221-B Building and 224-B Concentration Facility wastes. Single-shell tanks 241-B-202 through 241-B-204 were connected in series and began flowing into the cribs in December 1948. After August 1948, lanthanum/fluoride process waste from the 224-B Building was disposed directly to the cribs until October 1961. From December 1954 to October 1961, the unit received cell 5 and 6 drainage and equipment cleanout waste from the 224-B Concentration Facility. From October 1961 to May 1967, material disposed in these cribs consisted of decontamination construction waste from the 221-B Building. The cribs became inactive in 1967 (Brown and Ruppert 1950, WHC 1991).

The 216-B-7A&B Cribs are in line with an 8-cm (3-in.) steel inlet pipe that supplied waste to both cribs simultaneously. Each crib is a 4- by 4- by 1.2-m (12- by 12- by 4-ft) hollow (i.e., not gravel-filled) wooden structure made of 15- by 15-cm (6- by 6-in.) timbers, placed in a 4.2- by 4.2- by 4.2-m (14- by 14- by 14-ft) deep excavation. Figure 2-16 illustrates the construction of the cribs. Both cribs are classified as having cave-in potential.

Radionuclides contained within the waste streams discharged to the cribs included cesium-137, ruthenium-106, strontium-90, uranium, plutonium, and americium-241 (potentially at transuranic [TRU] levels) (Brown et al. 1990). Approximately 22,300,000 L (5,890,000 gal) of waste were jetted to the 241-B-201 through 241-B-204 SSTs between 1947 and 1950 from B Plant. An

estimated 10 g of plutonium and 20 Ci of fission products were sent from the 241-B-201 and 241-B-202 SSTs to the cribs (Brown and Ruppert 1950). Approximately 21,470,000 L (5,670,000 gal) ultimately reached the 216-B-7A&B Cribs. An additional 22,100,000 L (5,800,000 gal) of wastewater were discharged to the cribs after 1950 until they were taken out of service in 1967.

In 1992, the contaminated soil from the UPR-200-E-144 surface contamination area was scraped and consolidated on the 216-B-7A&B Cribs. The area was covered with approximately 0.45 to 0.61 m (18 to 24 in.) of clean backfill.

2.2.3.5 216-B-38 Trench. The 216-B-38 Trench is an inactive waste site located north of the 216-B-37 Trench, north of the B Plant, and west of the 241-BX Tank Farm. The trench, active only in July 1954, received 1,430,000 L (380,000 gal) of high salt, neutral/basic first-cycle supernatant waste from the 221-B Building via tanks 241-B-110, 241-B-111, and 241-B-112 (Maxfield 1979).

The 216-B-38 Trench is 77 m (250 ft) long, 3 m (10 ft) wide, and 3 m (10 ft) deep (Maxfield 1979). The unit was deactivated by removing the above-ground piping when specific retention was reached (Maxfield 1979).

Compounds in the liquid disposed to this site include fluoride, nitrate, nitrite, phosphate, sodium aluminate, sodium hydroxide, sodium silicate, and sulfate-based compounds from the bismuth/phosphate campaign. Radionuclides contained in the waste stream at the time of discharge included 510 Ci of cesium-137, 1,900 Ci of strontium-90, 560 Ci of ruthenium-106, 1.2 g of plutonium, and 42 kg of uranium (Maxfield 1979).

In October 1982, the trench was surface stabilized with 0.6 m (2 ft) of clean topsoil and treated with an herbicide.

Figure 2-1. Generalized Stratigraphic Column for the 200 Areas.

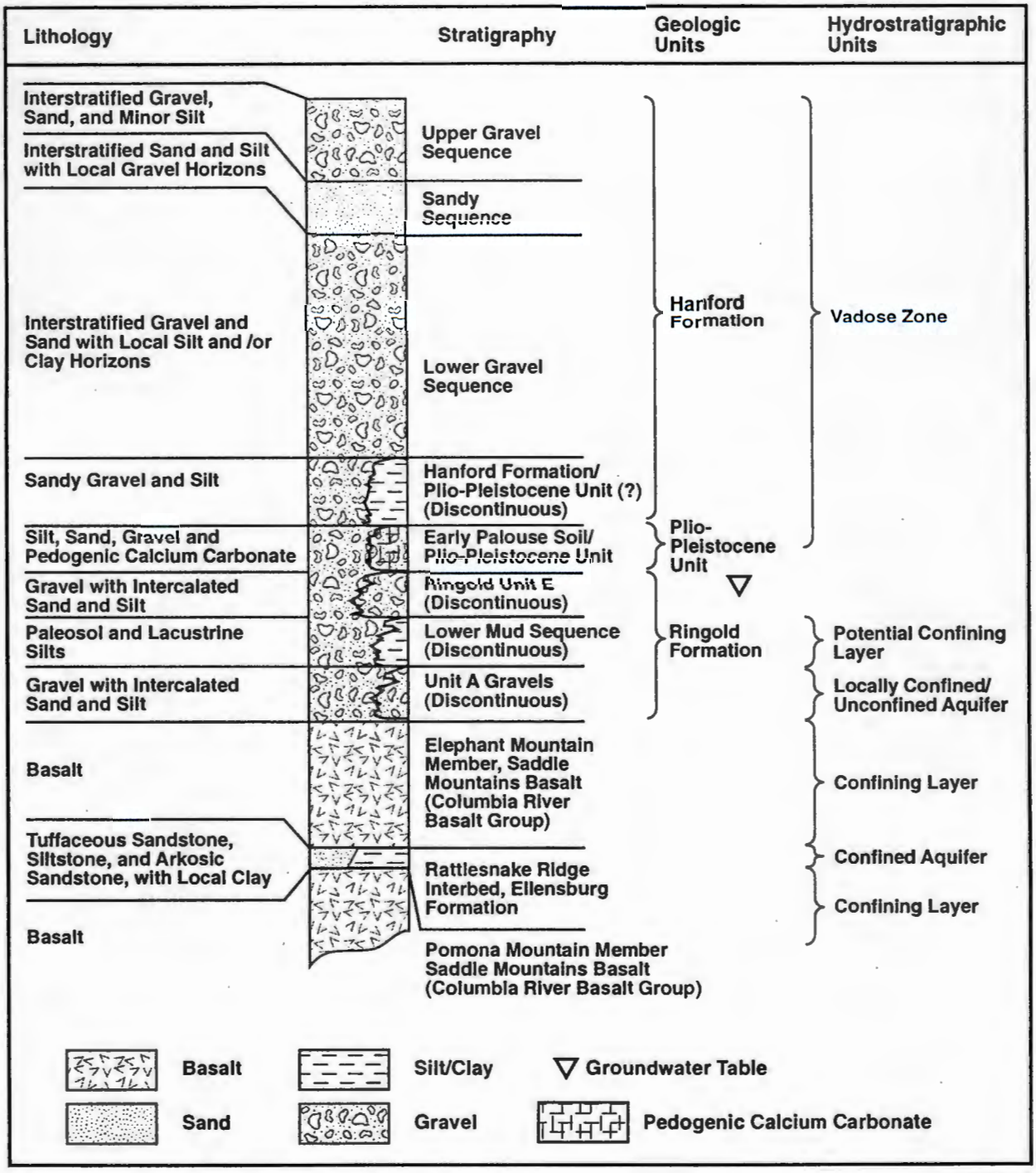


Figure 2-2. Groundwater Table Around the 200 East and West Areas, June 1999 (Modified from PNNL 2000).

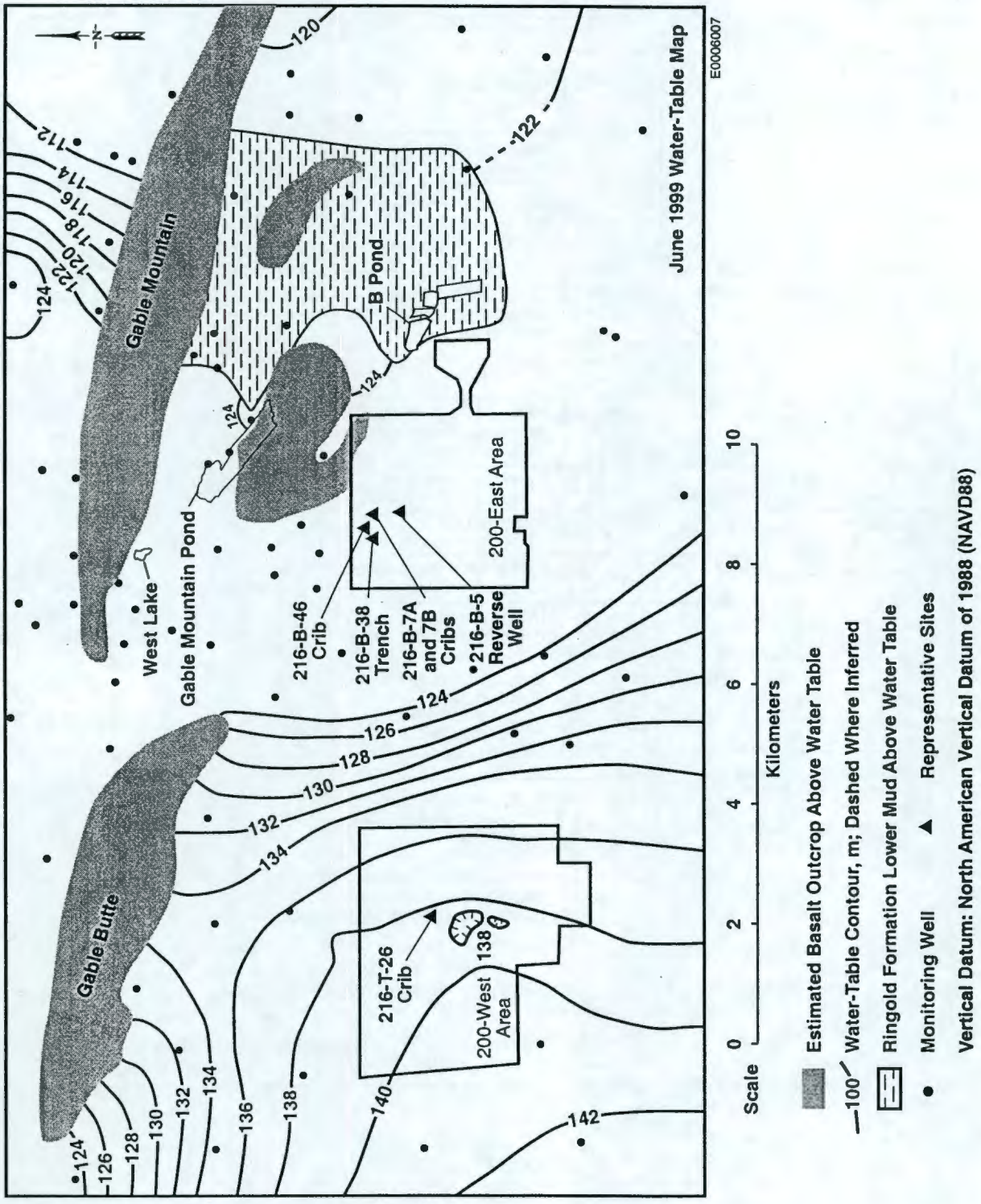


Figure 2-3. Stratigraphy in the Vicinity of the 216-B-46 Crib.

Well 299-E33-4

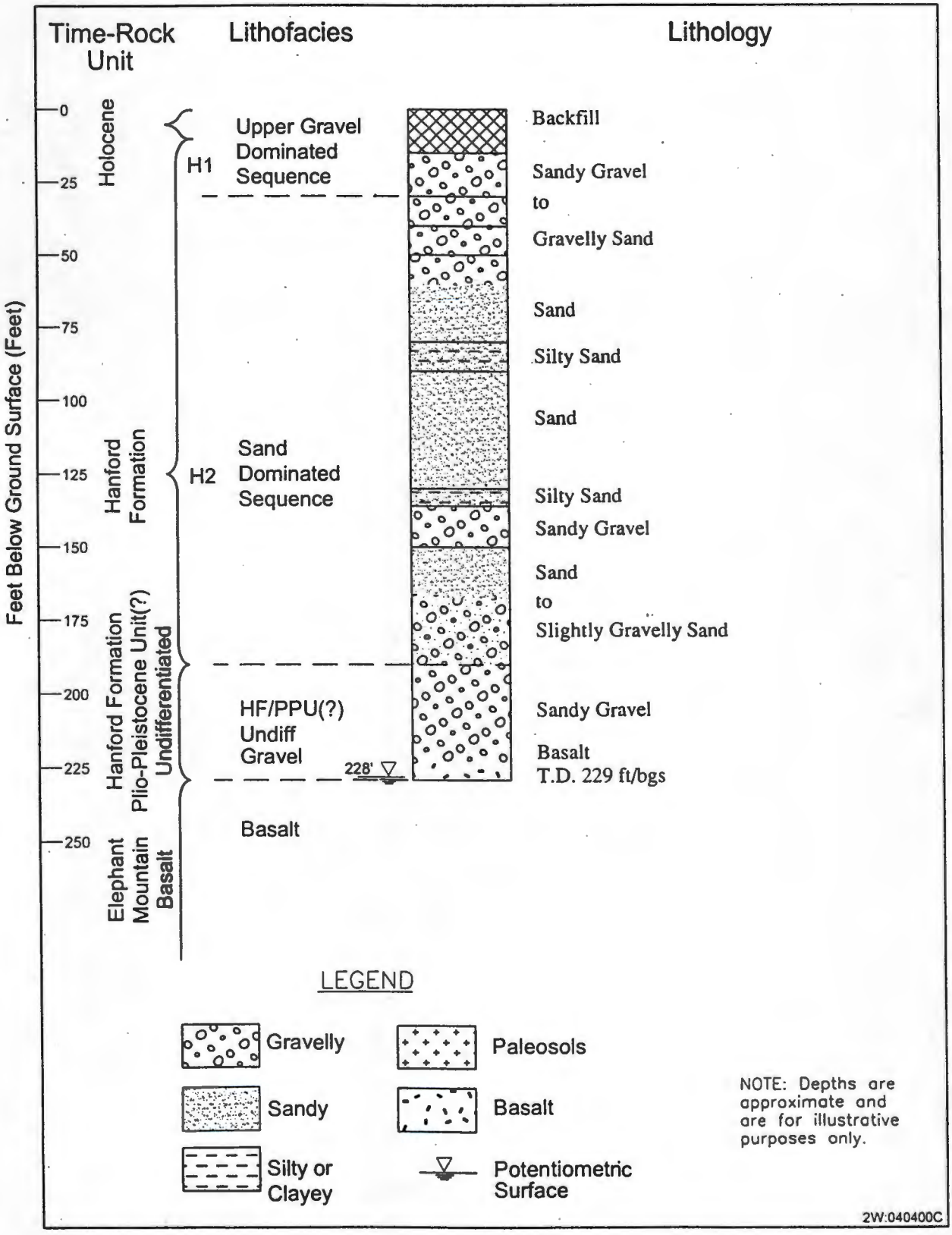


Figure 2-4. Stratigraphy Near the 216-T-26 Crib.

Well 299-W15-17/299-W11-26

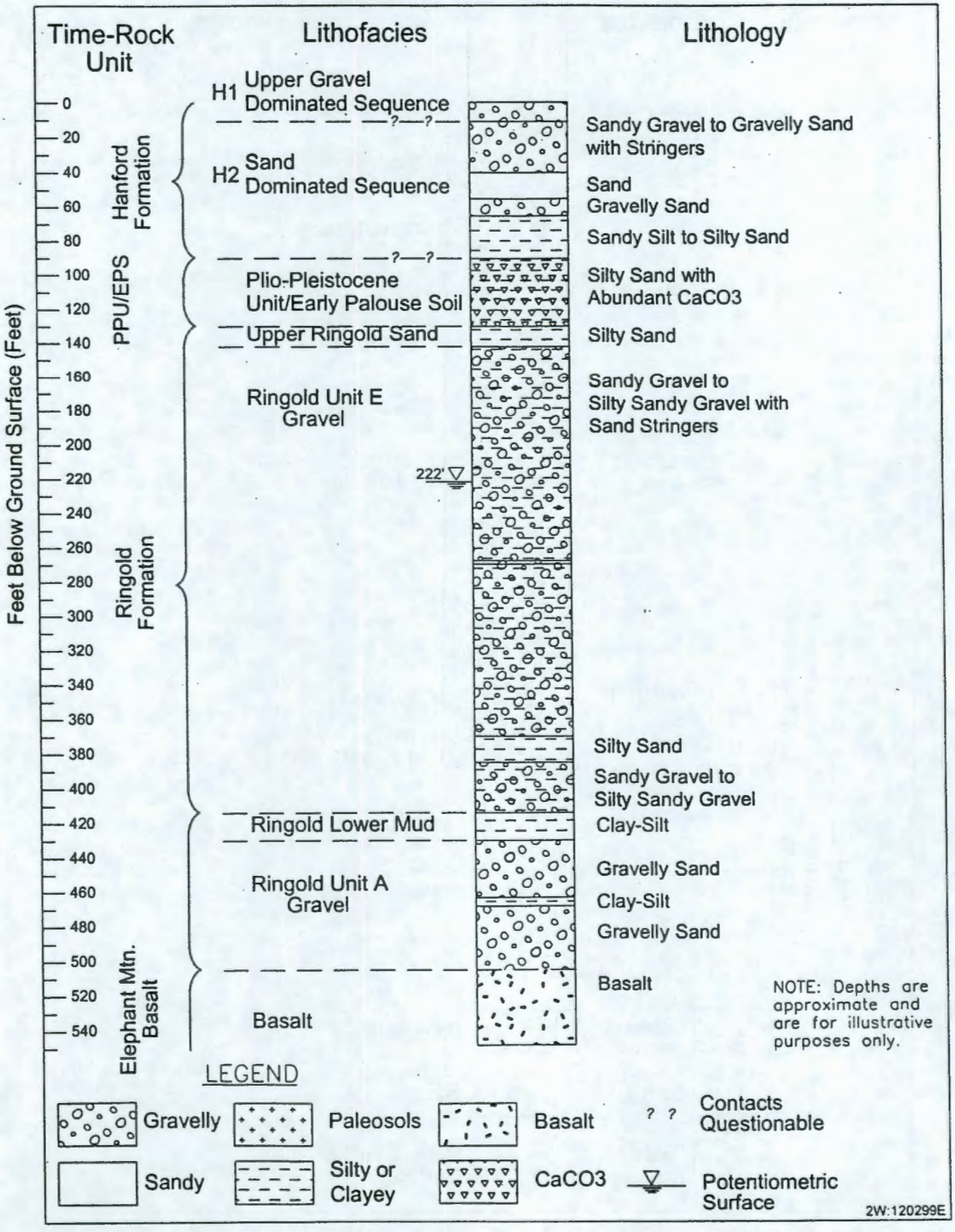


Figure 2-5. Stratigraphy Near the 216-B-5 Reverse Well.

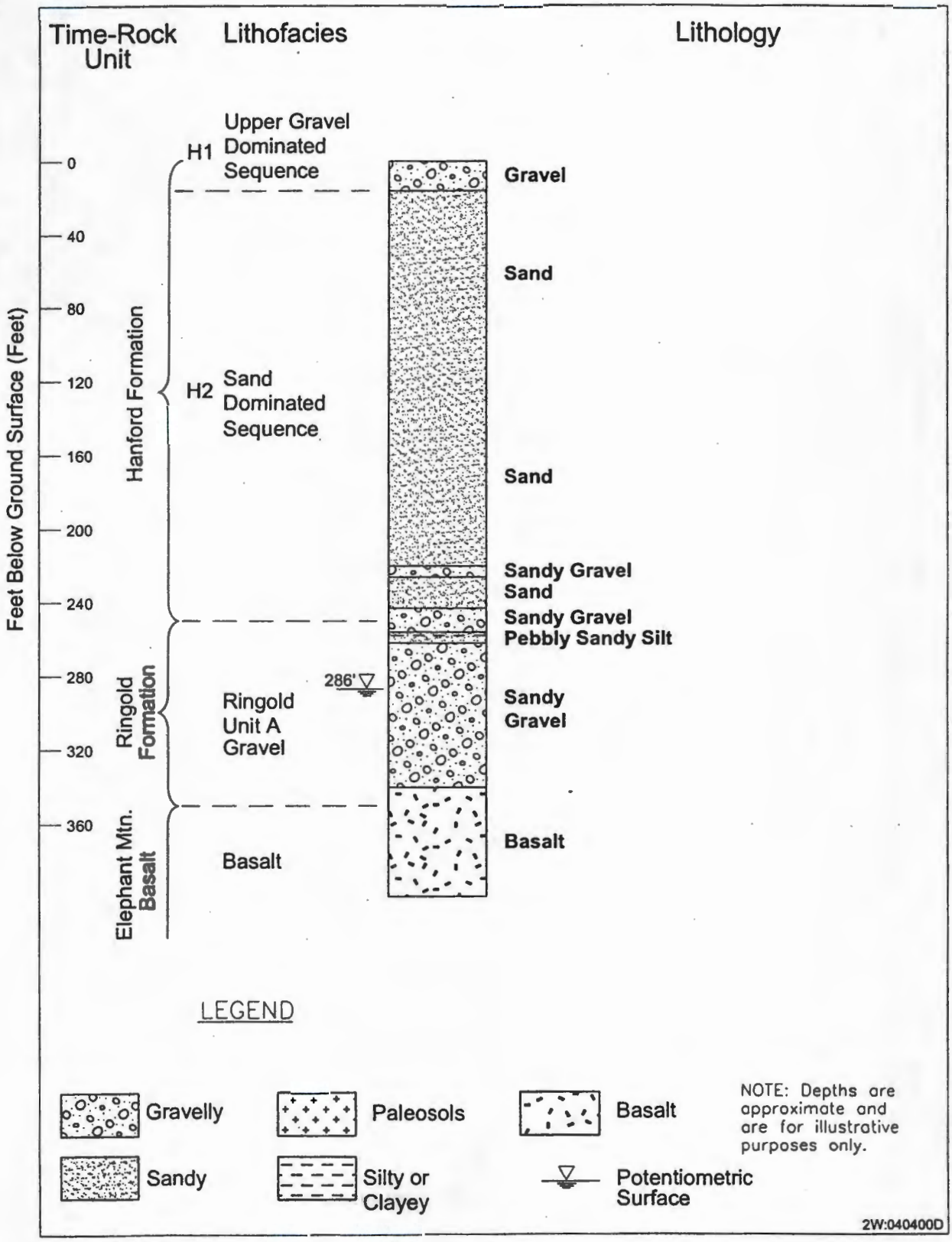


Figure 2-6. Stratigraphy Near the 216-B-7A&B Cribs.

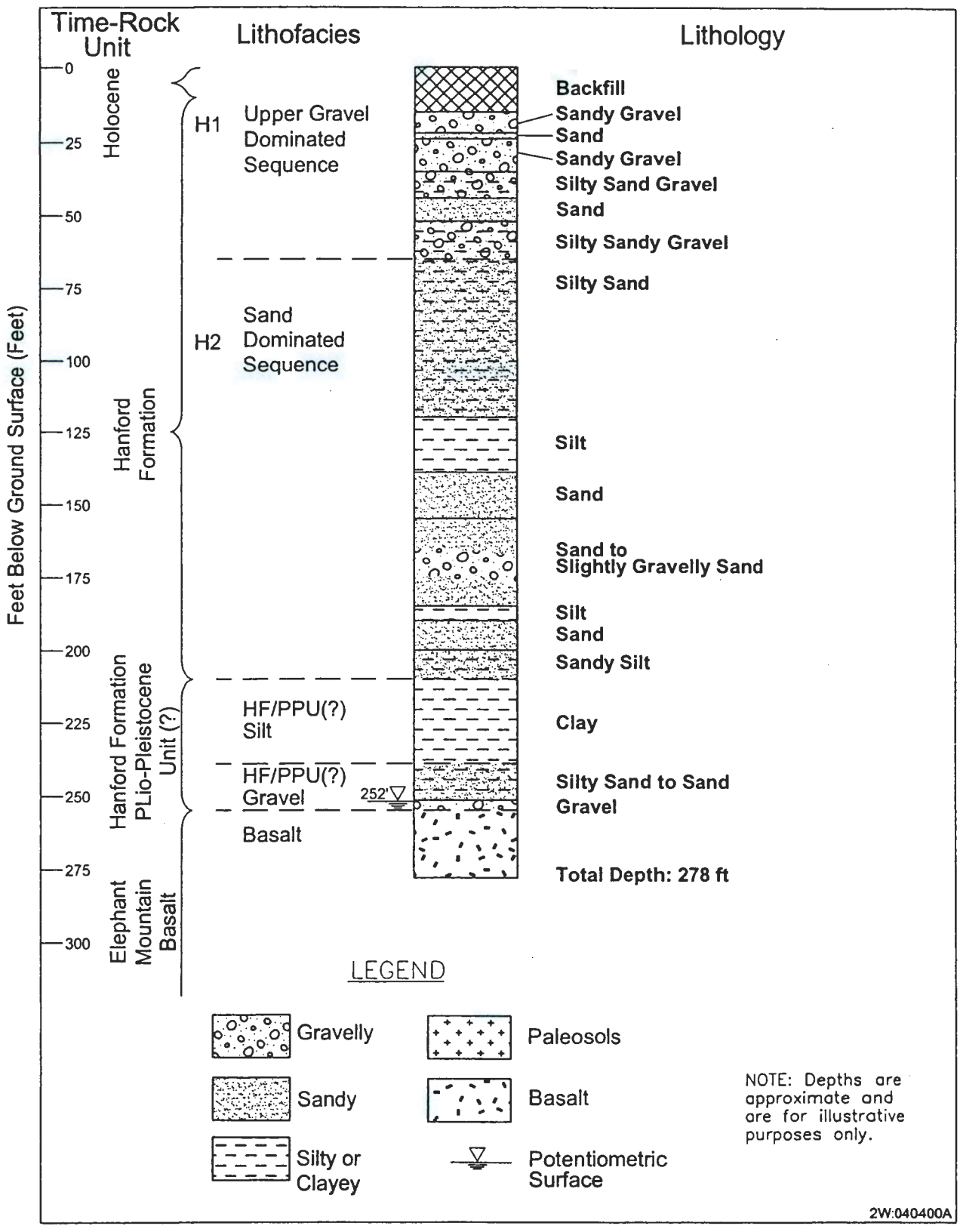


Figure 2-7. Stratigraphy in the Vicinity of the 216-B-38 Trench.

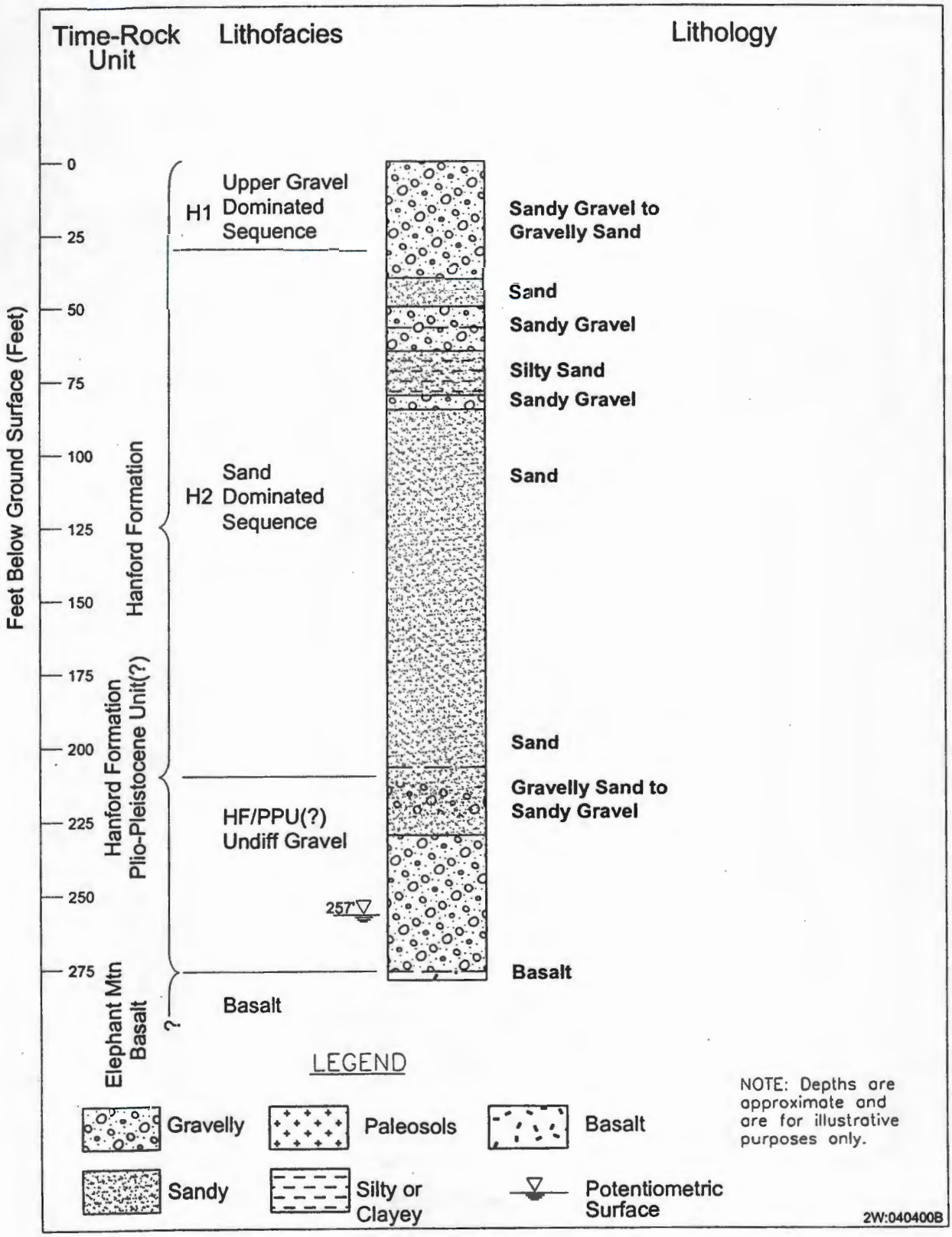


Figure 2-8. Location of the Hanford Site and 200-TW-1 and 200-TW-2 Operable Unit Waste Sites.

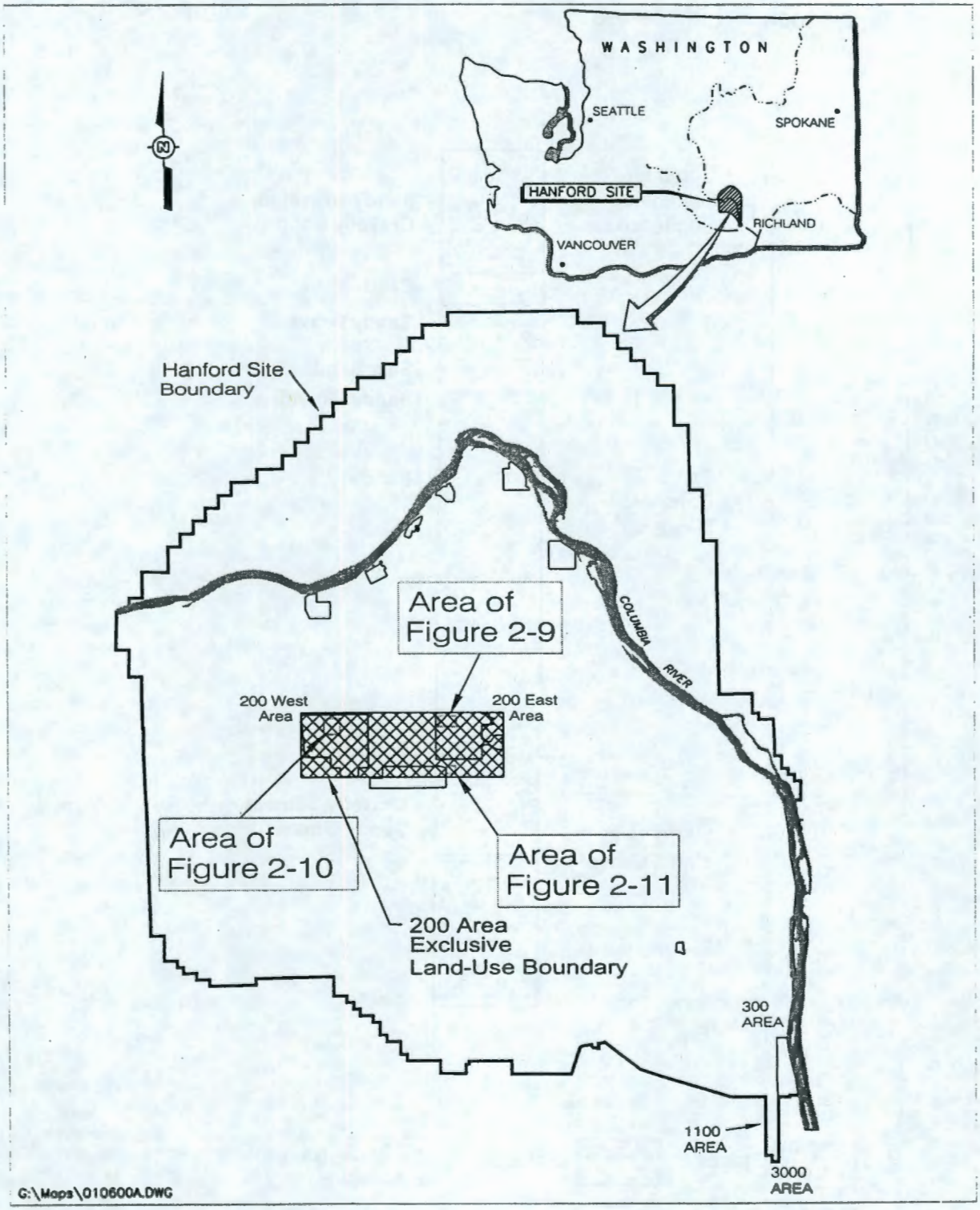
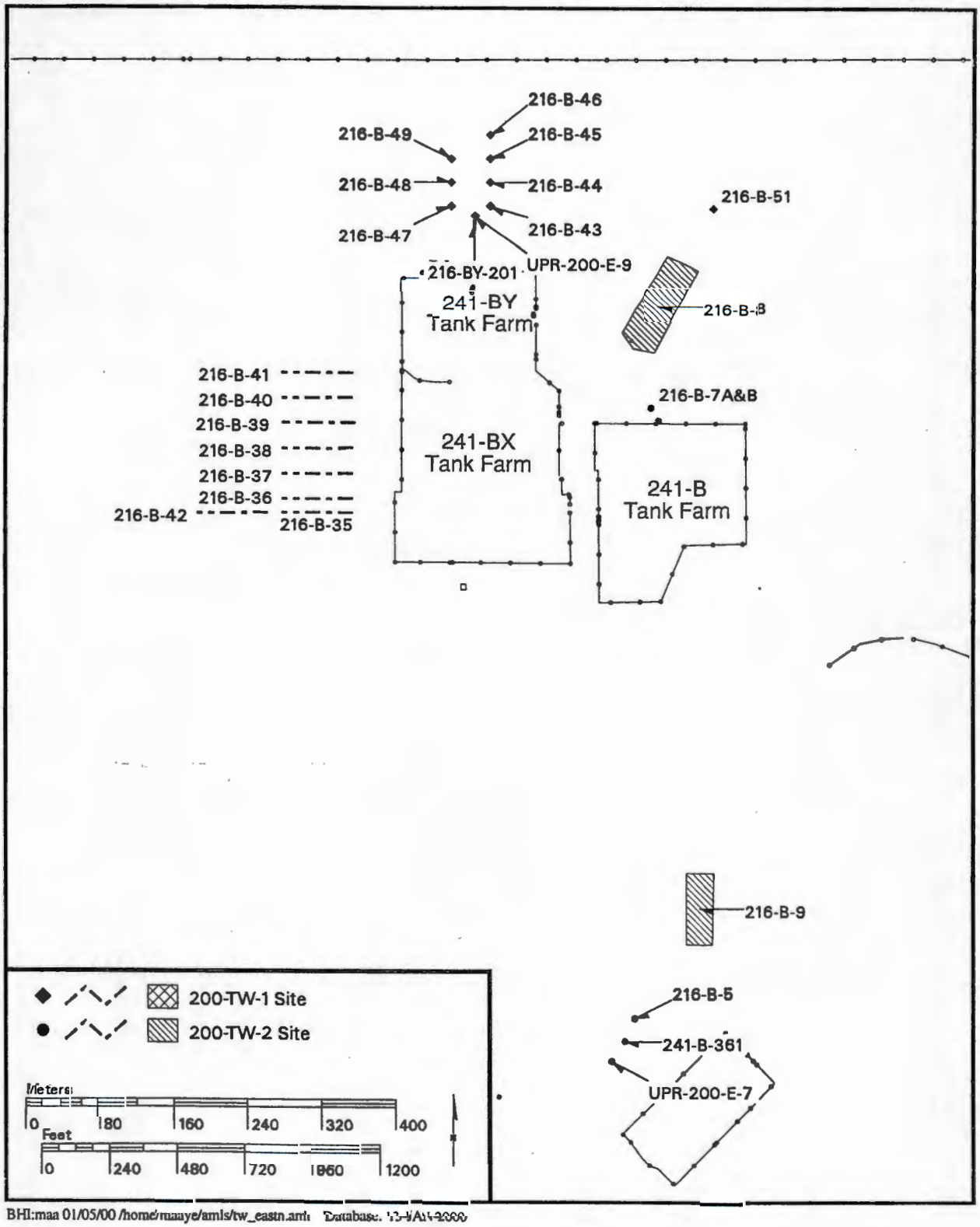
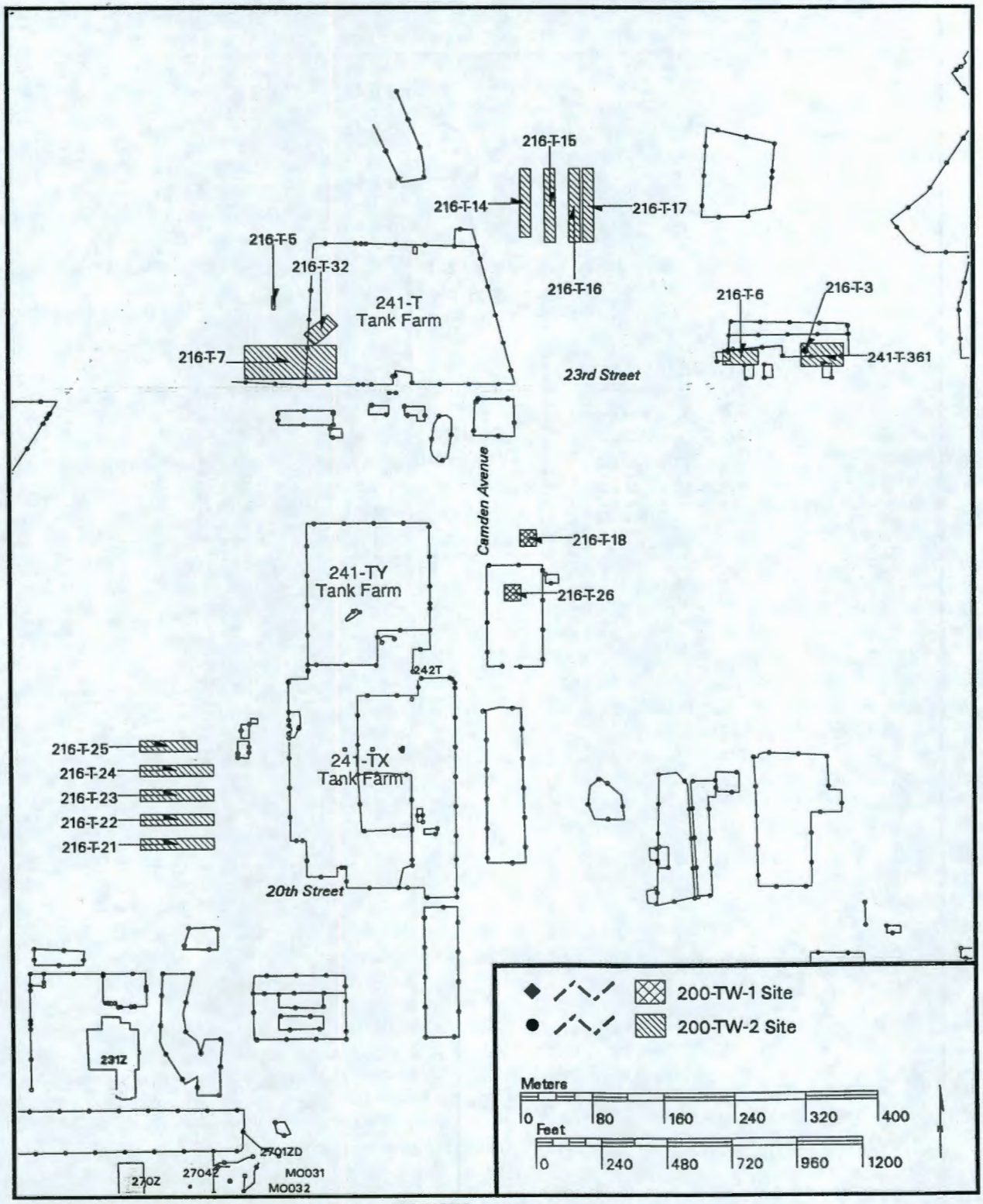


Figure 2-9. Location of 200-TW-1 and 200-TW-2 Waste Sites Inside the 200 East Area.



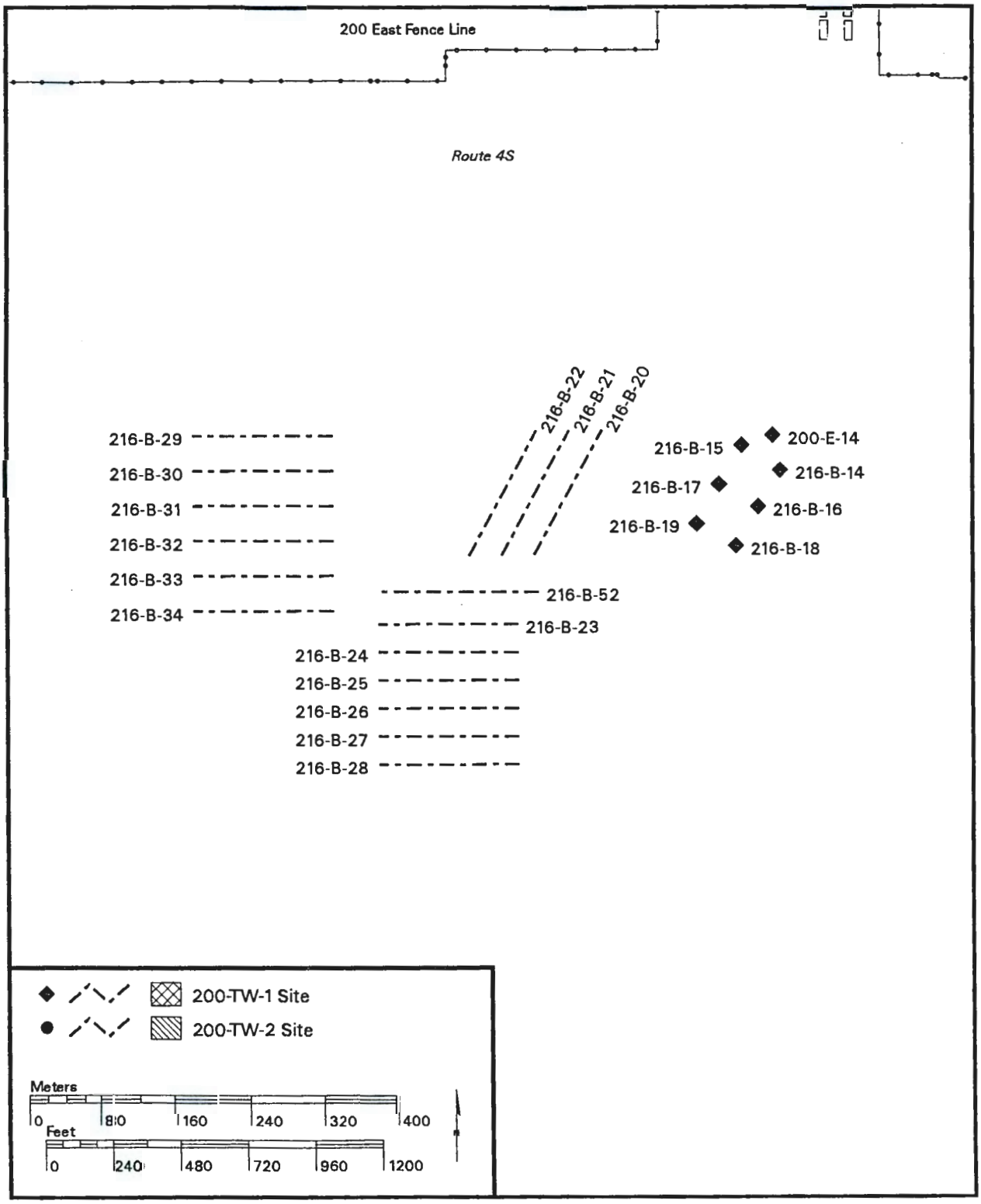
BHI:maa 01/05/00 /home/maaye/amls/tw_eastn.ami Database: 03-WA1-2000

Figure 2-10. Location of 200-TW-1 and 200-TW-2 Waste Sites in the 200 West Area.



BHI:maa 01/04/00 /home/maaye/amls/tw_west.aml Database: 13-JAN-2000

Figure 2-11. Location of 200-TW-1 and 200-TW-2 Waste Sites Adjacent to the 200 East Area.



BHI:maa 1/04/00 /home/maa/amls/tw_easts.aml Database: 13-JAN-2000

Figure 2-12. Source Facilities Associated with the 200-TW-1 and 200-TW-2 Operable Unit Waste Sites.

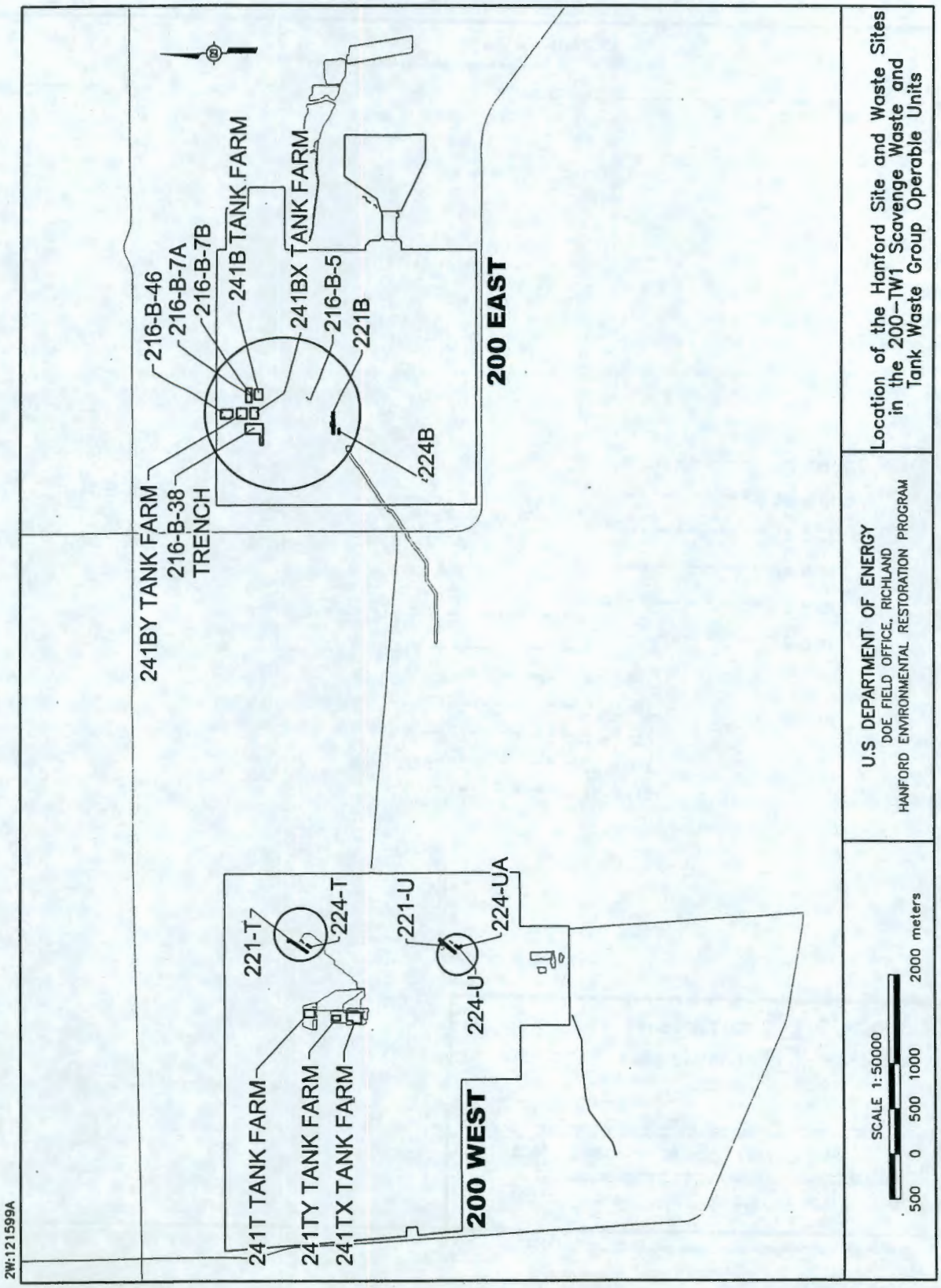


Figure 2-13. Plant Processes and Waste Streams at T and B Plants.

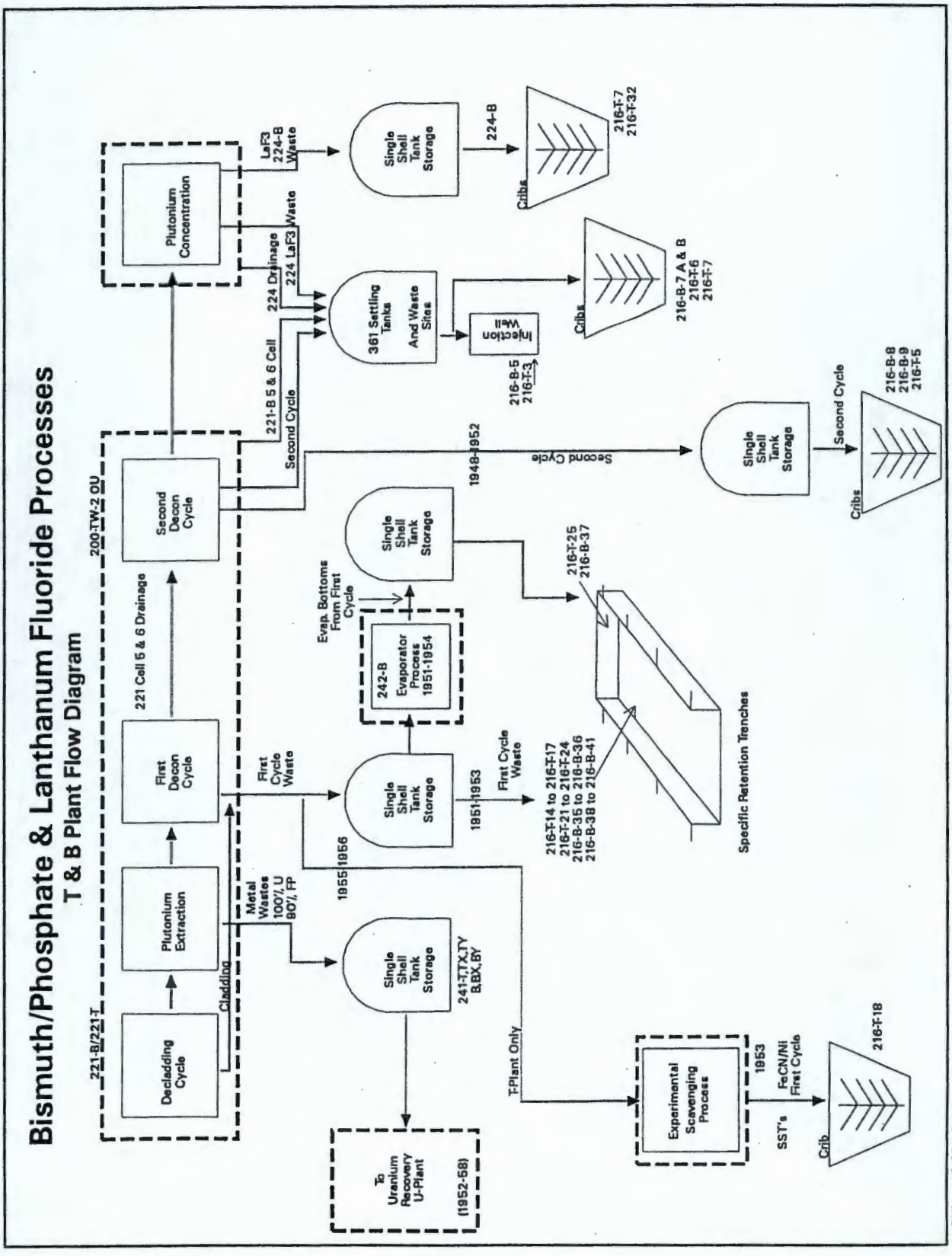


Figure 2-14. Plant Processes and Waste Streams at U Plant.

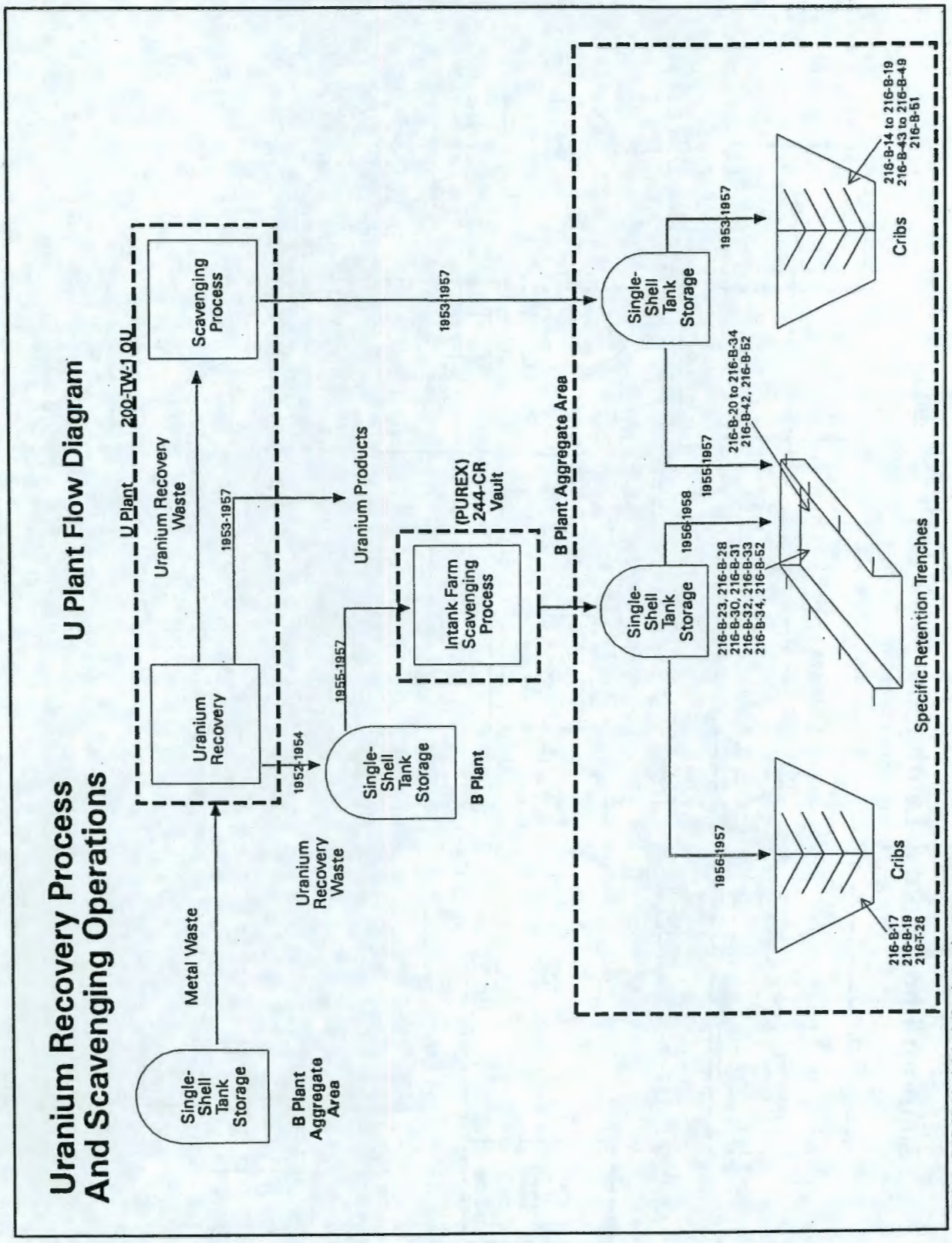


Figure 2-15. 216-B-46 and 216-T-26 Crib Construction Diagram.

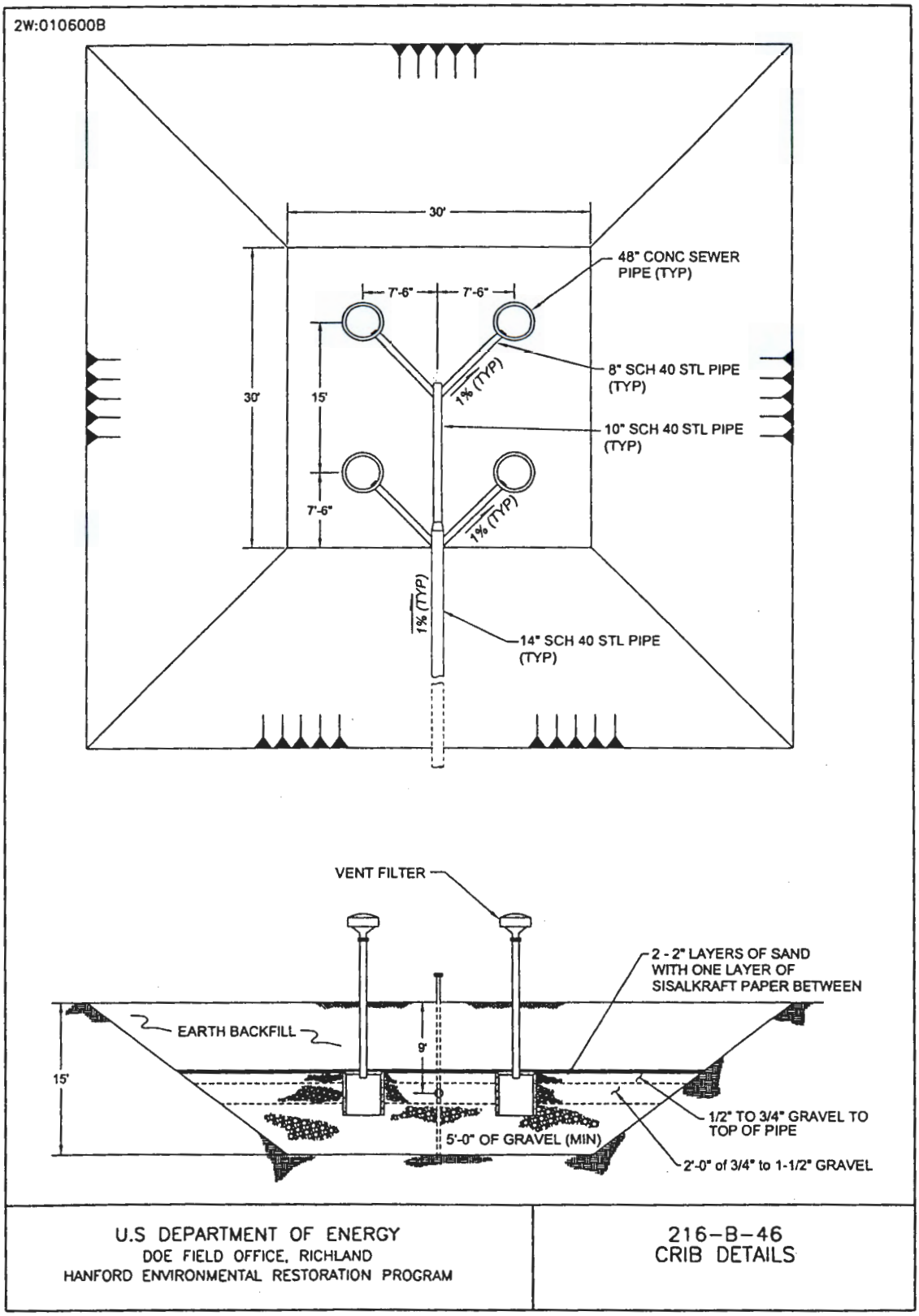


Figure 2-16. 216-B-7A&B Crib Construction Diagram.

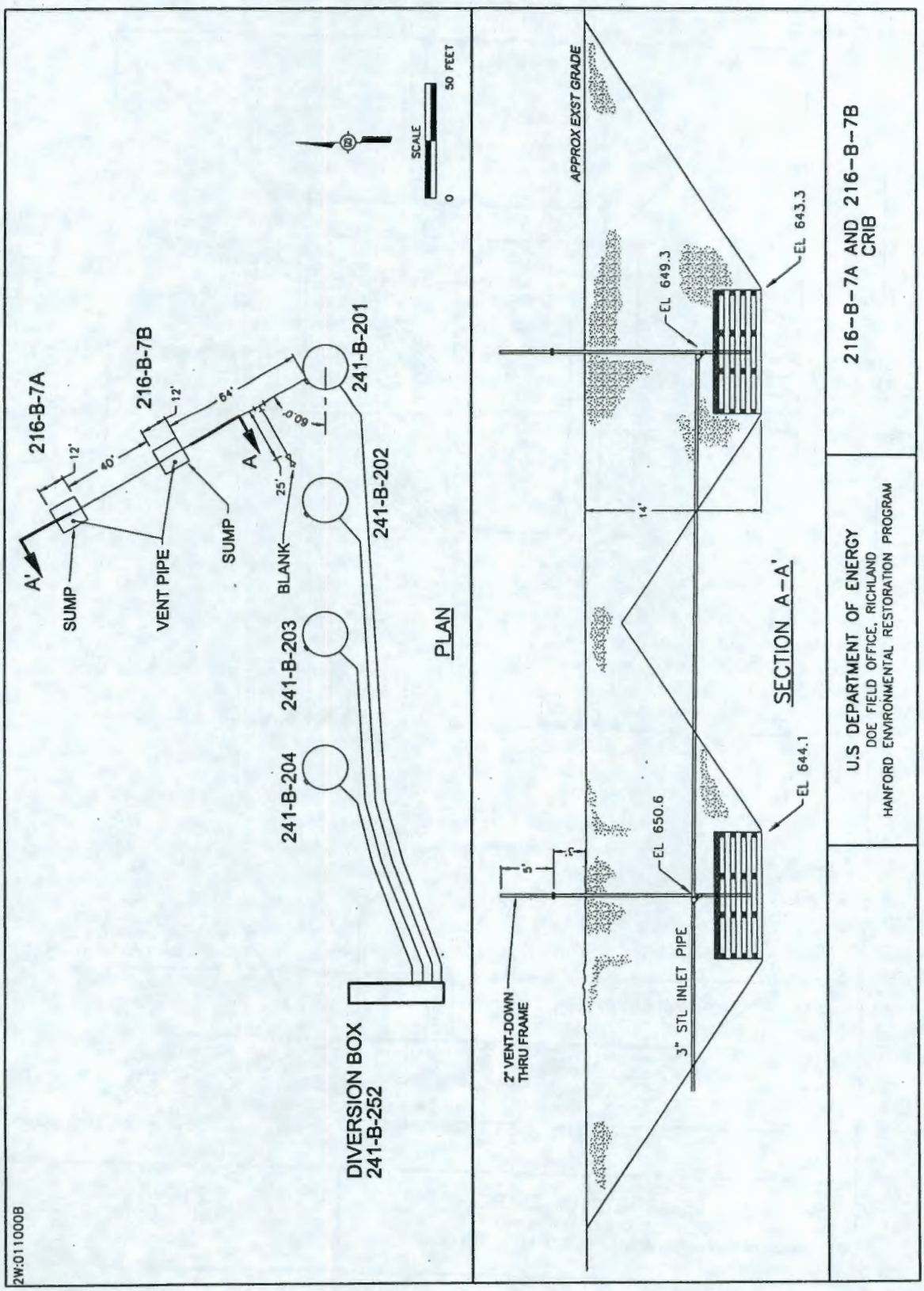


Table 2-1. Summary of Hydrogeologic Data at Representative Sites.

Site	Well #	Area	Waste Site Elevation	Bottom of Structure[a]	Hanford Unit 1[b]	Hanford Unit 2	Hanford Unit 3	PPU/EPS	Ringold Upper	Ringold Unit E	Ringold Lower Mud	Ringold Unit A	Depth to Water	Top of Basalt
216-B-5 Reverse Well[c]	E28-33	200 East	211 m (693 ft)	92 m 302 ft	0-4.8 m (0-16 ft)	4.8-76.3 m (16-250 ft)	0	0	0	0	0	76.3-103.7 m (250-340 ft)	87.5 m (287 ft)	101 (340 ft)
216-B 7A&B Cribs[d]	E33-18	200 East	199 m (652.7 ft)	1.2 m (4 ft)	0-19.8 m (0-65 ft)	19.8–64 m (65-210 ft)	64-74.7 m[e] (210-245 ft)	747-96.9 m[f] (245-252 ft)	0	0	0	0	76.9 m (252 ft)	76.9 m (252 ft)
216-B-38 Trench[d]	E33-8	200 East	202.5 m (664.4 ft)	3 m (10 ft)	0-9 m (0-30 ft)	9-64 m (30-210 ft)	64-77.5 m[g] (210-257 ft)	0	0	0	0	0	78.4 m (257 ft)	84.2 m (276 ft)
216-B-46 Crib[d]	E33-4	200 East	191 m (627 ft)	4.3 m (14 ft)	0-19 m (0-30 ft)	9-58 m (30-190 ft)	58-69.8 m[g] (190-229 ft)	0	0	0	0	0	68.5 m (228 ft)	69.8 m (229 ft)
216-T-26 Crib[h]	W1126/ W15-17	200 West	205 m (672.6 ft)	4.6 m (15 ft)	0-3.4 m (0-11 ft)	3.4-27.4 m (11-90 ft)	0	27.4-39.6 m (90-130 ft)	39.6-43.3 m (130-142 ft)	43.3-126.2 m (414-430 ft)	43.3-131.1 m (414-430 ft)	131.1-154 m (430-505 ft)	67.7 m (222 ft)	154 m (505 ft)

[a]Waste Information Data System.
[b]Waste site may include up to 4.6 m (15 ft) of backfill.
[c]Stratigraphy based on Smith (1980).
[d]Stratigraphy based on Wood et al. (2000)
[e]Hanford formation/Plio-Pleistocene unit (?) silt.
[f]Hanford formation/Plio-Pleistocene unit (?) gravel.
[g]Hanford formation/Plio-Pleistocene unit (?) undifferentiated gravel.
[h]Stratigraphy based on Swanson et al. (1999).
PPU/EPS = Plio-Pleistocene Unit/Early Palouse Soil
Well Prefix 299-

Table 2-2. Summary of Information for the 200-TW-1 Operable Unit. (6 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
200-E-14	200-E-14, 216-BC-201 Siphon Tank	South of Route 4S and 18 m (60 ft) north of the center between 216-B-14 and 216-B-15 Cribs	1956 to 1957	In-tank farm and scavenged $BiPO_4$ waste from UPR in 221-U	3.9×10^7 L liquid waste through tank from $BiPO_4$ and URP with Fe, CN, Sr, PO_4, TBP Total radionuclide content for tank and cribs: 26 Ci Co-60; 1,840 Ci Cs-137; 1,850 Ci Sr-90; 70g Pu; 1,410 kg U	NA	8.2 m x 3.9 m (27 ft x 13 ft)	The 216-B-14 to B-19 Cribs and 216-B-201 Siphon Tank were all stabilized together with 0.6 m (2 ft) of topsoil in 1981. Concrete AC 540 markers indicate the location. Tank is concrete and discharged waste to BC Cribs (B-14 to B-19). Tank received waste via underground 2805-E-3 and four pipelines.
216-B-14	216-B-14 Crib 216-BC-1 Crib	South of the 200 East Area (across Route 4S) in the BC Crib Area	1956 to 1956	Scavenged $BiPO_4$ waste from UPR in 221-U	8,710,000 L with Fe, CN, Sr, PO_4, TBP Total radionuclide content for tank and cribs: 26 Ci Co-60; 1,840 Ci Cs-137; 1,850 Ci Sr-90; 70g Pu; 1,410 kg U	4 m (13 ft)	24 m x 24 m[a] (80 ft x 80 ft)	The 216-B-14 to B-19 Cribs and 216-BC-201 Siphon Tank were all stabilized together with 0.6 m (2 ft) of topsoil in 1981. Concrete AC 540 markers indicate the location. Tank discharged waste to BC Cribs (B-14 to B-19). Cribs are constructed of wood, cinder block, and steel on a bed of 7.6-cm (3-in.) gravel. Waste routed to BC Cribs from 241-B, BX, and BY Tank Farms via drain B-51.
216-B-15	216-B-15 Crib 216-BC-2 Crib		1956 to 1957		6,320,000 L with Fe, CN, Sr, PO_4, TBP Total radionuclide content for tank and cribs: 26 Ci Co-60; 1,840 Ci Cs-137; 1,850 Ci Sr-90; 70g Pu; 1,410 kg U			
216-B-16	216-B-16 Crib 216-BC-3 Crib		1956 to 1956		5,600,000 L with Fe, CN, Sr, PO_4, TBP Total radionuclide content for tank and cribs: 26 Ci Co-60; 1,840 Ci Cs-137; 1,850 Ci Sr-90; 70g Pu; 1,410 kg U			
216-B-17	216-B-17 Crib 216-BC-4 Crib		1956 to 1956	In tank farm scavenged (1st cycle) and scavenged $BiPO_4$ waste from UPR in 221-U	3,410,000 L with Fe, CN, Sr, PO_4, TBP Total radionuclide content for tank and cribs: 26 Ci Co-60; 1,840 Ci Cs-137; 1,850 Ci Sr-90; 70g Pu; 1,410 kg U			
216-B-18	216-B-18 Crib 216-BC-5 Crib		1956 to 1956	Scavenged $BiPO_4$ waste from UPR in 221-U	8,520,000 L with Fe, CN, Sr, PO_4, TBP Total radionuclide content for tank and cribs: 26 Ci Co-60; 1,840 Ci Cs-137; 1,850 Ci Sr-90; 70g Pu; 1,410 kg U			

Table 2-2. Summary of Information for the 200-TW-1 Operable Unit. (6 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
216-B-19	216-B-19 Crib 216-BC-6 Crib		1957 to 1957	In-tank farm scavenged (1st cycle) and scavenged $BiPO_4$ waste from UPR in 221-U	6,400,000 L with Fe, CN, Sr, PO_4, TBP Total radionuclide content for tank and cribs: 26 Ci Co-60; 1,840 Ci Cs-137; 1,850 Ci Sr-90; 70g Pu; 1,410 kg U			
216-B-20	216-B-20 Trench 216-BC-7 Trench		1956 to 1956	Scavenged $BiPO_4$ waste from UPR in 221-U	4,680,000 L with Fe, CN, Sr, PO_4, TBP Surface radiological contamination	3 m (10 ft)	153 m x 3 m[b] (500 ft x 10 ft)	The unlined BC Trenches (B-20 to B-34) were each backfilled upon reaching capacity. The BC Trenches were stabilized together in 1969 with sand and gravel; in 1981 and1982 with clean soil. Concrete AC 540 markers outline the group of trenches. URP/scavenged liquid extraction waste was routed to trenches from 241-B, BX, and BY Tank Farms via drain B-51. Surface contamination spread through rabbits and vegetation has resulted in ongoing stabilization efforts.
216-B-21	216-B-21 Trench 216-BC-8 Trench	West side of the 216-B-20 Trench, south of the 200 East Area (across Route 4S) in the BC Crib Area						See general description for 216-B-20. Groundwater well 299-E13-83 monitors site.
216-B-22	216-B-22 Trench 216-BC-9 Trench	West side of the 216-B-21 Trench, south of the 200 East Area (across Route 4S)			4,740,000 L with Fe, CN, Sr, PO_4, TBP Surface radiological contamination			See general description for 216-B-20. Groundwater well 299-E13-9 monitors site.
216-B-23	216-B-23 Trench 216-BC-10 Trench	South of the 200 East Area (across Route 4S)			4,520,000 L with Fe, CN, Sr, PO_4, TBP Surface radiological contamination	5.4 m (18 ft); 2.4 m (8 ft) is overburden		See general description for 216-B-20.
216-B-24	216-B-24 Trench 216-BC-11 Trench	Directly south of the 216-B-23 Trench, south of the 200 East Area (across Route 4S) in the BC Crib Area			4,700,000 L with Fe, CN, Sr, PO_4, TBP Surface radiological contamination			See general description for 216-B-20. Groundwater well 299-E13-11 monitors site.

Table 2-2. Summary of Information for the 200-TW-1 Operable Unit. (6 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
216-B-25	216-B-25 Trench 216-BC-12 Trench	Directly south of the 216-B-24 Trench, south of the 200 East Area (across Route 4S) in the BC Crib Area	1956 to 1956	Scavenged $BiPO_4$ waste from UPR in 221-U	3,760,000 L with Fe, CN, Sr, PO_4, TBP Surface radiological contamination	6.2 m (20 ft); 3 m (10 ft) is overburden		See general description for 216-B-20.
216-B-26	216-B-26 Trench 216-BC-13 Trench	Directly south of the 216-B-25 Trench, south of the 200 East Area (across Route 4S)	1956 to 1957		5,880,000 L with Fe, CN, Sr, PO_4, TBP Surface radiological contamination	5.5 m (18 ft); 2.4 m (8 ft) is overburden		See general description for 216-B-20. Groundwater well 299-E13-12 monitors site.
216-B-27	216-B-27 Trench 216-BC-14 Trench	Directly south of the 216-B-26 Trench, south of the 200 East Area (across Route 4S)	1957		4,420,000 L with Fe, CN, Sr, PO_4, TBP Surface radiological contamination			See general description for 216-B-20.
216-B-28	216-B-28 Trench 216-BC-15 Trench	Directly south of the 216-B-27 Trench, south of the 200 East Area (across Route 4S)			5,050,000 L with Fe, CN, Sr, PO_4, TBP Source of surface radiological contamination	3 m (10 ft)		See general description for 216-B-20. Groundwater wells 299-E13-13 and 299-E13-19 monitor site.
216-B-29	216-B-29 Trench 216-BC-16 Trench	South of the 200 East Area (across Route 4S) in the BC Crib Area			4,840,000 L with Fe, CN, Sr, PO_4, TBP Surface radiological contamination			See general description for 216-B-20. Groundwater well 299-E13-14 monitors site.
216-B-30	216-B-30 Trench 216-BC-17 Trench	Directly south of the 216-B-29 Trench; south of the 200 East Area (across Route 4S) in the BC Crib Area			4,780,000 L with Fe, CN, Sr, PO_4, TBP Surface radiological contamination			See general description for 216-B-20.
216-B-31	216-B-31 Trench 216-BC-18 Trench	Directly south of the 216-B-30 Trench; south of the 200 East Area (across Route 4S) in the BC Crib Area			4,740,000 L with Fe, CN, Sr, PO_4, TBP Surface radiological contamination			See general description for 216-B-20. Groundwater wells 299-E13-15 and 299-E13-16 monitor site.
216-B-32	216-B-32 Trench 216-BC-19 Trench	Directly south of the 216-B-31 Trench; south of the 200 East Area (across Route 4S) in the BC Crib Area			4,770,000 L with Fe, CN, Sr, PO_4, TBP Surface radiological contamination			See general description for 216-B-20.
216-B-33	216-B-33 Trench 216-BC-20 Trench	Directly south of the 216-B-32 Trench; south of the 200 East Area (across Route 4S) in the BC Crib Area			4,740,000 L with Fe, CN, Sr, PO_4, TBP Surface radiological contamination			See general description for 216-B-20.

Table 2-2. Summary of Information for the 200-TW-1 Operable Unit. (6 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
216-B-34	216-B-34 Trench 216-BC-21 Trench	Directly south of the 216-B-33 Trench; south of the 200 East Area (across Route 4S) in the BC Crib Area			4,870,000 L with Fe, CN, Sr, PO_4, TBP Surface radiological contamination			See general description for 216-B-20.
216-B-42	216-B-42 Trench 241-BX-8 Grave 216-BX-8 Trench	North of B Plant and west of the 241-BX Tank Farm	1955		1,500,000 L with Fe, CN, Sr, PO_4, TBP		77 m x 3 m[b] (253 ft x 10 ft)	The unlined trenches (B-35 to B-42) were each backfilled upon reaching capacity. Trenches were stabilized together in 1982 with 0.6 m (2 ft) of clean soil. Concrete AC 540 markers outline the group of trenches. URP/scavenged liquid extraction waste was routed to trenches via 241-B, BX, and BY Tank Farms.
216-B-43	216-B-43 Crib 216-BY-1 Crib 216-BY-1 Cavern	North of 241-BY Tank Farm and west of Baltimore Avenue in a common area with 216-B-44 through 216-B-50	1954		2,100,000 L with Fe, CN, Sr, PO_4, TBP	4.3 m (14 ft)	23 m x 23 m[a] (75 ft x 75 ft)	The B-43 to B-49 Cribs received URP/ scavenged liquid extraction waste routed via 241-BY Tank Farm. Once the B-43 to B-49 Cribs were full, waste was sent to the BC Cribs and Trenches. Each crib has a 1.2-m (4-ft)-diameter x 1.2-m (4-ft) length concrete culvert, buried vertically with centers spaced 4.6 m (15 ft) apart in a 9.1- x 9.1- x 4.6-m (30- x 30- x 15-ft) excavation. Cribs were wrapped in plastic and sand. Cribs B-43 to B-50 were stabilized together in 1975 with 0.3 m (1 ft) clean soil. Contaminated soil from UPR-200-E-89 was consolidated onto B-43 to B-50 Cribs and covered with 0.6 m (2 ft) of clean fill in 1991. A light chain outlines the group of cribs.
216-B-44	216-B-44 Crib 216-BY-2 Crib 216-BY-2 Cavern	North of 241-BY Tank Farm and west of Baltimore Avenue in a common area with 216-B-43 through 216-B-50	1954 to 1955		5,600,000 L with Fe, CN, Sr, PO_4, TBP			
216-B-45	216-B-45 Crib 216-BY-3 Crib 216-BY-3 Cavern		1955		4,900,000 L with Fe, CN, Sr, PO_4, TBP			
216-B-46	216-B-46 Crib 216-BY-4 Crib 216-BY-4 Cavern				6,700,000 L with Fe, CN, Sr, PO_4, TBP			

Table 2-2. Summary of Information for the 200-TW-1 Operable Unit. (6 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
216-B-47	216-B-47Crib 216-BY-5 Crib 216-BY-5 Cavern				3,700,000 L with Fe, CN, Sr, PO_4, TBP			
216-B-48	216-B-48 Crib 216-BY-6 Crib 216-BY-6 Cavern				4,100,000 L with Fe, CN, Sr, PO_4, TBP			
216-B-49	216-B-49 Crib 216-BY-7 Crib 216-BY-7 Cavern				6,700,000 L with Fe, CN, Sr, PO_4, TBP			
216-B-51	216-B-51 Crib 216-BY-9 Crib	South of 12th Street and east of Baltimore Avenue; north of 241-B Tank Farm	1956 to 1958		1,000 L with Fe, CN, Sr, PO_4, TBP Site contains less than 10 Ci of total beta contamination.		1.5 m (5 ft) diameter	The french drain routed waste from BY Tank Farms to the BC Cribs and Trenches. The unit is a concrete pipe extending 0.3 m (1 ft) above ground and 4.3 m (14 ft) below ground, filled with 4 m (13 ft) of gravel, with a wooden cover. In 1992, soil was scraped around B-51 from UPR-200-E-144 and placed on 216-B-7A&B Cribs.
216-B-52	216-B-52 Trench	Immediately north of 216-B-23 Trench; south of the 200 East Area (across Route 4S) in the BC Crib Area	1957 to 1958		5,530,000 L with Fe, CN, Sr, PO_4, TBP Surface radiological contamination	3 m (10 ft)	177 m x 3 m[b] (580 ft x 10 ft)	This unlined BC Trench was backfilled upon reaching capacity. BC Trenches were stabilized together in 1969 with sand and gravel in 1981 and in 1982 with clean soil. Concrete AC 540 markers outline the group of Trenches. URP/scavenged liquid extraction waste was routed to trenches from 241-BY Tank Farm via drain B-51. Surface contamination due to rabbits and vegetation has resulted in ongoing stabilization efforts.

Table 2-2. Summary of Information for the 200-TW-1 Operable Unit. (6 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
216-BY-201	216-BY-201 Settling Tank 241-BY Flush Tank 216-BY-47	Northwest portion of 200 East Area; north of 241-BY Tank Farm; south of 216-B-43 through 50 cribs.	1954 to 1958	Radionuclide waste from 241-BY Tank Farms and scavenged $BiPO_4$ solvent extraction waste from UPR in 221-U	No listed volume; contaminants include Fe, CN, Sr, PO_4, TBP, Na, Al, CO_3, OH Radionuclides: Sr, Cs, Y, Ba	4.3 m (14 ft), 1.5 m (5 ft) is overburden	12.5 m x 1.9 m (41 ft x 6 ft)	The flush tank is a rectangular, reinforced concrete structure that received waste from the 241-BY Tank Farm and TBP waste stream. The unit was used to perform "In-Tank" scavenging and discharged the supernatant to the B-43 to B-49 Cribs. In 1955 the tank overflowed, causing UPR-200-E-9. The soil was scraped and placed southeast of 216-B-43. The flush tank was then covered with 3 m (10 ft) of clean soil.
216-T-18	216-T-18 Crib 216-T-17 241-T-17 Crib	Northeast of 241-TY Tank Farm and north of 216-T-26 Crib	1953	1st Cycle from T Plant and Scavenged $BiPO_4$ solvent extraction waste from UPR in 221-U	1,000,000 L with Fe, CN, Sr, PO_4, TBP, Na, Al, CO_3, OH, NO_3, SO_4, PO_4, NO_2, SiO_3, $NaAlO_2$, F Radionuclides: 1,800 g Pu; Sr; Cs; Y; Ba	4.6 m (15 ft)	9 m x 9 m (30 ft x 30 ft)	Experimental scavenging waste generated in 221-T was discharged to T-18; records are unclear about TBP waste to this crib. Documentation supports that the waste discharged to T-18 was generated in T-221 in 1953 and that T-18 was a "test crib" that received U-221 waste. The crib consists of steel inlet pipe that branches into four steel pipes, each extending to an open-ended, concrete sewer pipe. Once capacity was reached, the crib was backfilled with gravel and covered with soil. The site was stabilized in 1990. Concrete AC-540 markers indicate the site. Groundwater well 299-W11-11 monitors the site.
216-T-26	216-T-26 Crib 216-TY-1 Cavern 216-TY-1 Crib 241-TX-1 Cavern 216-TX-1 Crib	Inside 200 West Area, south of 23rd Street and east of Camden Avenue	1955 to 1956	1st Cycle from T Plant and scavenged $BiPO_4$ solvent extraction waste from UPR in 221-U	12,000,000 L with Fe, CN, Sr, PO_4, TBP, Na, Al, CO_3, OH, NO_3, SO_4, PO_4, NO_2, SiO_3, $NaAlO_2$, F Radionuclides: 1,800 g Pu; Sr; Cs; Y; Ba	4.6 m (15 ft)		Waste was piped via underground pipeline. Site also received waste of 216-TY-201 flush tank after cascading through 241-TY-101, 103, and 104. Surface contamination from vegetation uptake required an excavation of topsoil and addition of backfill for stabilization in 1975 and 1990.
UPR-200-E-9	UPR-200-E-9, Liquid Overflow at 216-BY-201	Adjacent to 216-BY-201 Flush Tank, north of 241-BY Tank Farm	1955	Radionuclide Waste from 241-BY Tank Farms and scavenged $BiPO_4$ solvent extraction waste from UPR in 221-U	41,800 L with Fe, CN, Sr, PO_4, TBP, Na, Al, CO_3, OH Radionuclides: Sr, Cs, Y, Ba	NA	NA	The contaminated soil was scraped and placed southeast of 216-B-43 and covered with 0.9 m (3 ft) of clean soil. The flush tank was covered with 3 m (10 ft) of clean soil. Surface contamination north of 241-BY Tank Farm was later named UPR-200-E-89.

[a]Surface of waste site.
[b]Bottom of waste site.

Table 2-3. Summary of Information for the 200-TW-2 Operable Unit. (7 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminants/Volumes Released	Waste Site Depth (bgs)	Waste Site Dimensions	General Description
216-B-5	216-B-5 Reverse Well 241-B-361 Reverse Well 241-B-361 Dry Well, 241-B-5 Dry Well	East of Baltimore Avenue and south of 216-B-9 Crib	1945 to 1947	Supernatant overflow from settling tank 241-B-361 in 221-B Building and liquid waste from 224-B Building	31,000,000 L, including 4.3 kg Pu and 3,800 Ci of beta/gamma	92 m (302 ft)	92 m x 20 cm diameter (302 ft x 8 in. diameter)	In 1947, well 299-E33-18 indicated that contamination had impacted groundwater. Waste was rerouted to 216-B-7A&B Cribs. Eleven additional wells were drilled to monitor groundwater (299-E23-1, 299-E27-1, 299-E28-1 to -7). Plume extend 610 m (2,000 ft) laterally. Surface stabilized in 1994 with 61 cm (24 in.) crushed concrete.
216-B-7A&B	216-B7A&B Cribs, 241-B-201 Crib, 216-B-7 Crib, 216-B-7A Sump, 216-B-7B Sump, 241-B-1&2	North of 241-B Tank Farm and east of Baltimore Avenue	1946 to 1967	Overflow from tanks B-201 to B-204 of 2nd cycle waste, cell 5/6 drainage, 221-B, 224-B. From 1961 to 1967 received decontamination waste from 221-B	Total of 43,600,000 L waste up to 1958 from 221- and 224-B with 4.3 kg Pu and 5400 Ci beta/gamma; 752,000 L decontamination waste with 2,100 Ci beta/gamma contamination including 14 Ci Cs-137; 2,080 Ci Sr-90	4.3m (14 ft)	3.7 m x 3.7 m x 1.2 m deep (12 ft x 12 ft x 4 ft deep)	Two wooden cribs approximately 6 m (20 ft) apart. Each was placed in a 4.3- x 4.3- x 4.3-m (14- x 14- x 14-ft) excavation. Cribs are beneath an area of contaminated soil from UPR-200-E-144. 60 cm (24 in.) of clean backfill was used to stabilize in 1992. Cesium, cobalt, tritium, and alpha contamination was detected in groundwater samples of well 299-E33-18 in 1967.
216-B-8	216-B-8 Crib, 241-B-3 Crib, 216-B-8TF	93 m (305 ft) north of the 241-B Tank Farm, east of Baltimore Avenue, north of 216-B-7A&B Cribs	1948 to 1954	2nd cycle waste from 221-B via 241-B-110, 111, 112 tanks. Tank 104-B sludge sent 1948 (1st and 2nd cycle, 5/6 cell drainage, 221 and 224-B decontamination wastes)	27,200,000 L with 30 g Pu, 45 kg U, 710 Ci of fission products, citric and HCl acids; sludge has 990 µg Pu per kg of material and 9,000 µCi per kg of sludge	7 m (23 ft)	3.7 m x 3.7 m x 2.1 m deep (12 ft x 12 ft x 7 ft)	Wooden crib was placed in a 4.3- x 4.3- x 4.3-m (14- x 14-x 23-ft) excavation. The tile field is 91 m (300 ft) long and 30.5 m (100 ft) wide. Tile field was fed by a VCP trunk with eight 21.3-m (70-ft) pipes branching off. Waste disposed via 361 settling tank to cribs until 1951. Contaminated soil from UPR-200-E-144 was added and site was stabilized in 1992 with backfill. The Heath Instrument Shaft (HIS) is adjacent to the left and within bounds of crib and tile field.

Table 2-3. Summary of Information for the 200-TW-2 Operable Unit. (7 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminants/Volumes Released	Waste Site Depth (bgs)	Waste Site Dimensions	General Description
216-B-9	216-B-9 Crib, 241-B-361 Crib, 5-6 Crib and Tile Field, 216-B-361 Crib, 216-B-9TF	East of Baltimore Avenue, 381 m (1,250 ft) south of the 241-B Tank Farm	1948 to 1951	Cell 5/6 drainage in 221-B was sent to B-9, bypassing the 241-B-361 Settling Tank	18,400,000 L; 95 g Pu and 2,050 Ci of fission products and alpha contamination; citric and HCl acids; 1,000 kg of nitrate; 36,000,000 L of cell 5/6 drainage; 4,000,000 L of crib overflow to tile field	NR	59 m x 19.5 m (194 ft x 64 ft)	216-B-9 Crib and Tile Field were built to replace 216-B-5. Acid used to dissolve the sludge that plugged crib. Crib sealed with sludge and overflowed to the tile field. Wooden crib is 4.3 x 4.3 m (14 x 14 ft). Tile field is 54.9 x 25.6 m (180 ft x 84 ft). In 1991, 0.6 m (2 ft) of clean backfill was added and site was planted to stabilize. Alpha contamination noted in wells 299-E28-57, 58, 59. Site associated with 241-B-154 Diversion Box and UPR-200-E-7.
216-B-35	216-B-35 Trench, 241-BX-1 Grave, 216-BX-1 Trench	North of B Plant and 60 m (200 ft) west of the 241-BX Tank Farm	1954	1st cycle supernatant from 221-B	1,060,000 L with F, NO_3, NO_2, PO_4, Na, $NaAlO_2$, NaOH, Na_2SiO_3, SO_4; 430 Ci Cs, 240 Ci Sr, 230 Ci Ru, 1.2 g Pu, 17 kg U	3 m (10 ft)	77 m x 3 m (250 ft x 10 ft)	216-B-35 through B-42 Trenches were surface stabilized with 0.6 m (2 ft) of soil in 1982. Treated with 2,4-d amine and seeded. Identified by concrete AC-540 markers. B-35 is the southern-most trench. Each additional trench is north of the previous one listed.
216-B-36	216-B-36 Trench, 241-BX-2 Grave, 216-BX-2 Trench				1,940,000 L 1st cycle waste from 221-B: F, NO_3, NO_2, PO_4, Na, $NaAlO_2$, NaOH, Na_2SiO_3, SO_4; 770 Ci Cs, 490 Ci Sr, 470 Ci Ru, 1 g Pu, 16 kg U			
216-B-37	216-B-37 Trench, 241-BX-3 Grave, 216-BX-3 Trench			Trench received evaporator bottoms from 242-B after 1st cycle supernatant from 221-B had been processed, also received direct 1st cycle waste	4,320,000 L 1st cycle waste from 221-B: F, NO_3, NO_2, PO_4, Na, $NaAlO_2$, NaOH, Na_2SiO_3, SO_4; 1 Ci Co, 3,100 Ci Cs, 16 Ci Sr, 500 Ci Ru, 2 g Pu, 3.6 kg U			
216-B-38	216-B-38 Trench, 241-BX-4 Grave, 216-BX-4 Trench			Trench received 1st cycle supernatant from 221-B	1,430,000 L 1st cycle waste from 221-B: F, NO_3, NO_2, PO_4, Na, $NaAlO_2$, NaOH, Na_2SiO_3, SO_4; 510 Ci Cs, 1,900 Ci Sr, 560 Ci Ru, 1.2 g Pu, 42 kg U			

Table 2-3. Summary of Information for the 200-TW-2 Operable Unit. (7 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminants/Volumes Released	Waste Site Depth (bgs)	Waste Site Dimensions	General Description
216-B-39	216-B-39 Trench, 241-BX-5 Grave, 216-BX-5 Trench		1953 to 1954		1,470,000 L 1st cycle waste from 221-B: F, NO_3, NO_2, PO_4, Na, $NaAlO_2$, NaOH, Na_2SiO_3, SO_4; 450 Ci Cs, 23 Ci Sr, 65 Ci Ru, 1.5 g Pu, 5.8 kg U			
216-B-40	216-B-40 Trench, 241-BX-6 Grave, 241-BX-6 Trench, 216-BX-6 Trench		1954		1,640,000 L 1st cycle waste from 221-B: F, NO_3, NO_2, PO_4, Na, $NaAlO_2$, NaOH, Na_2SiO_3, SO_4; 350 Ci Cs, 280 Ci Sr, 240 Ci Ru, 1 g Pu, 35 kg U			
216-B-41	216-B-41 Trench, 241-BX-7 Grave, 216-BX-7 Trench				1,440,000 L 1st cycle waste from 221-B: F, NO_3, NO_2, PO_4, Na, $NaAlO_2$, NaOH, Na_2SiO_3, SO_4; 890 Ci Cs, 47 Ci Sr, 130 Ci Ru, 0.3 g Pu, 7.5 kg U			
216-T-3	216-T-3 Reverse Well, 241-T-362-A Dry Well or Reverse Well, 362-T Reverse Well	Northwest of the 241-T-361 Settling Tank and northeast of the 216-T-6 Crib	1945 to 1946	Process effluent from 221-T and 224-T via 241-T-361 Settling Tank. Liquid included cell 5&6 drainage	11,300,00 L 221-T (5/6 cell drainage) and 224-T: NO_3, K, Na, PO_4, NH_4, F, SO_4, C_2O_4; 3,350 g Pu, 21 g Cs-137, 19 g Sr-90	63 m (206 ft)	63 m x 20 cm diameter (206 ft x 8 in. diameter)	Well drilled to 63 m (206 ft). Groundwater is approximately 87 m (285 ft) bgs. Well 299-W11-7 monitors site. Profiles completed in 1977 do not agree with disposal history. Radionuclide contamination was found 4.6 to 33 m (15 to 108 ft) bgs, but perforations started at 32 m (105 ft) bgs. Contamination may be due to failure in the casing or the 216-T-6 Cribs or 241-T-361 Settling Tank
216-T-5	216-T-5 Trench, 216-T-5 Grave, 216-T-12, 241-T-5 Trench	West side of the 241-T Tank Farm and northwest of the 216-T-32 Crib	1955	2nd Cycle supernatant from 221-T via T-112 Settling Tank	2,600,000 L: NO_3; Na_2SiO_3; Na; PO_4, NH_4, F; SO_4; 180 g Pu, 0.002 g U-238, 31 g Cs-137, 0.4 g Sr-90, 0.1 g Co-60	3.7 m (12 ft)	15 m x 3 m (50 ft x 10 ft)	Enclosed within chained barricades that also encompass 216-T-7 Crib and Tile Field. Well W10-1 monitors site.

Table 2-3. Summary of Information for the 200-TW-2 Operable Unit. (7 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminants/Volumes Released	Waste Site Depth (bgs)	Waste Site Dimensions	General Description
216-T-6	216-T-6 Cribs, 241-T-361 (1&2 Cribs), 216-T-5, 361-T-1&2 Cribs	North of 23rd Street, southwest of the 216-T Tile Field and 221 Canyon bldg., adjacent to 216-T-3 Injection Well and 241-T-361 Settling Tank	1946 to 1951	Liquid waste from 221-T and 224-T via 241-T-361 Tank included cell 5&6 drainage	45,000,000 L 221-T (5/6 cell drainage) and 224-T: NO_3, Na, PO_4, NH_4, F, SO_4, C_2O_4; 0.008 g U-238, 110 g Cs-137, 124 g Sr-90, 0.03 g Co-60	7.6 m (25 ft)	4.3 m x 4.3 m[b] (14 ft x 14 ft) (bottom of cribs)	Two wooden cribs, located approximately 19 m (62 ft) apart, connected in series. Cribs received waste after 216-T-3 was full. Once cribs were full, 221 waste went to 216-T-7 Crib and 224 waste went to 216-T-32. 13 groundwater wells monitor the site. Pu was detected at 6 m (20 ft) below cribs at a concentration of 0.04 µCi/g and spread approximately 13.7 m (45 ft) laterally. Fission products were detected at a depth of 33 m (107 ft) and laterally approximately 29 m (95 ft); the concentration was 0.05 µCi/g.
216-T-7	216-T-7 Crib and Tile Field, 216-T-7TF, 216-T-7 Tile Field, 241-T-3 Tile Field	Adjacent to the west side of the 241-T Farm fence and north of the 216-T-36 Crib and 23rd Street	1948 to 1955	2nd cycle supernatant from 221-T via 241-T-110-112 Settling Tanks from 1948-51; from 221-T, including cell drainage from 1951-52, and 221 and 224 wastes from 1952-55	110,000,000 L: NO_3, K, Na_2SiO_3, Na, PO_4, NH_4, F, SO_4 130 g Pu; 3,060 g U-238; 21 g Cs-137; 24 g Sr-90; 0.01 g Co-60	NR	95 m x 26 m (310 ft x 84 ft)	Crib connects via outlet pipe to a tile field. Crib is located within tank farm fence and tile field is outside. Once cribs were full, 221 and 224 wastes went to 216-T-19. Wells W10-3 and W10-69 monitor groundwater. 1.8 m (6 ft) of radionuclide contamination migration within soil column reported from 1959 to 1976.
216-T-14	216-T-14, 241-T-1 Trench, 216-T-1 Grave, 216-T-13	North of 23rd St. and northeast of the 241-T Tank Farm	1954	1st cycle supernatant and liquid effluent from metal cladding dissolution from 221-T Building via 241-T-104 to 106 tanks	1,000,000 L 1st cycle waste from 221-T: F, NO_3, NO_2, PO_4, Na, $NaAlO_2$, NaOH, Na_2SiO_3, SO_4, 0.9 g Pu; 30,000 g U-238; 204 g Cs-137; 2.5 g Sr-90; 0.2 g Co-60; 0.8 g H-3	3 m (10 ft)	84 m x 3 m[b] (275 ft x 10 ft)	216-T-14 to T-17 Trenches were stabilized as one unit and are identified by concrete AC-540 markers. Dimensions are for bottom of trench. Herbicides (trisdendimethylamine) used to control radionuclide contaminated weeds in 1970. Trenches were stabilized with contaminated soil from UPR-200-W-166 and covered with 0.6 m (2 ft) clean soil. Well 299-W-11-68 monitors the site. Profile in 1976 shows radiological contamination at 9 m (30 ft) bgs.

Table 2-3. Summary of Information for the 200-TW-2 Operable Unit. (7 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminants/Volumes Released	Waste Site Depth (bgs)	Waste Site Dimensions	General Description
216-T-15	216-T-15, 241-T-2 Trench, 241-T-2 Grave, 216-T-14, 216-T-15 Crib				1,000,000 1st cycle waste from 221-T: F, NO_3, NO_2, PO_4, Na, $NaAlO_2$, NaOH, Na_2SiO_3, SO_4, 0.9 g Pu; 26,000 g U-238; 450 g Cs-137; 8.6 g Sr-90; 0.2 g Co-60; 0.8 g H-3			
216-T-16	216-T-16, 241-T-3 Trench, 241-T-3 Grave, 216-T-15, 216-T-16 Crib				1,000,000 L 1st cycle waste from 221-T: F, NO_3, NO_2, PO_4, Na, $NaAlO_2$, NaOH, Na_2SiO_3, SO_4, 0.7 g Pu; 21,000 g U-238; 227 g Cs-137; 3.3 g Sr-90; 0.2 g Co-60; 0.8 g H-3			
216-T-17	216-T-17, 241-T-4 Trench, 216-T-4 Grave, 216-T-16				785,000,000 L 1st cycle waste from 221-T: F, NO_3, NO_2, PO_4, Na, $NaAlO_2$, NaOH, Na_2SiO_3, SO_4; 0.5 g Pu; 20,000 g U-238; 162 g Cs-137; 1.2 g Sr-90; 0.2 g Co-60; 0.6 g H-3			
216-T-21	216-T-21 Trench, 241-TX-1 Trench, 216-TX-1 Grave, 216-TX-3	West of the 241-TX Tank Farm and north of the 231-Z Building		1st cycle supernatant and liquid effluent from metal coating dissolving from 221-T Building via 241-T-109 to 111 tanks	465,000 L 1st cycle waste from 221-T: F, NO_3, NO_2, PO_4, Na, $NaAlO_2$, NaOH, Na_2SiO_3, SO_4, 1 g Pu; 521 g U-238; 174 g Cs-137; 3.3 g Sr-90; 0.3 g Co-60; 0.4 g H-3	3 m (10 ft)	74 m x 3 m (240 ft x 10 ft)	216-T-21 to T-25 Trenches were stabilized as one unit and identified by concrete AC-540 markers. Dimensions are for bottom of trench. Herbicides (trisdendimethylamine) used to control radionuclide contaminated weeds in 1969. Well 299-W-15-80 monitors site. Profile in 1976 shows band of radionuclides from 10.7 to 16.8 m (35 to 55 ft) bgs.
216-T-22	216-T-22 Trench, 241-TX-2 Trench, 216-TX-2 Grave, 216-TX-4				1,530,000 L 1st cycle waste from 221-T: F, NO_3, NO_2, PO_4, Na, $NaAlO_2$, NaOH, Na_2SiO_3, SO_4, 2 g Pu; 2,170 g U-238; 803 g Cs-137; 21 g Sr-90; 0.02 g Co-60; 1.2 g H-3			

Table 2-3. Summary of Information for the 200-TW-2 Operable Unit. (7 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminants/Volumes Released	Waste Site Depth (bgs)	Waste Site Dimensions	General Description
216-T-23	216-T-23, 241-TX-3 Trench, 216-TX-3 Grave, 216-TX-5, 241-TX-3 Grave				1,480,000 L 1st cycle waste from 221-T: F, NO_3, NO_2, PO_4, Na, $NaAlO_2$, NaOH, Na_2SiO_3, SO_4, 1 g Pu; 1,086 g U-238; 577 g Cs-137; 17 g Sr-90; 0.02 g Co-60; 1.2 g H-3			
216-T-24	216-T-24, 241-TX-4 Trench, 216-TX-4 Grave, 216-TX-6				1,530,000 L 1st cycle waste from 221-T: F, NO_3, NO_2, PO_4, Na, $NaAlO_2$, NaOH, Na_2SiO_3, SO_4, 2 g Pu; 8,320 g U-238; 617 g Cs-137; 16 g Sr-90; 0.02 g Co-60; 1.2 g H-3			
216-T-25	216-T-25 Trench, 241-TX-5 Trench, 216-TX-5 Grave, 216-TX-7			Condensed evaporator bottoms from 1st cycle and metal coating liquid effluent from 242-T Evaporator	3,000,000 L 1st cycle waste from 221-T: F, NO_3, NO_2, PO_4, Na, $NaAlO_2$, NaOH, Na_2SiO_3, SO_4, 1 g Pu; 1,110 g U-238; 3,860 g Cs-137; 1.7 g Sr-90; 0.02 g Co-60; 2.4 g H-3		55 m x 3 m (180 ft x 10 ft)	
216-T-32	216-T-32 Crib, 241-T #1 & 2 Cribs, 216-T-6	West side of the 241-T Farm and north of 216-T-7 Crib	1946 to 1952	224-T Building waste via tank 241-T-201 after 216-T-6 Crib was full. Deactivated due to sludge build-up in diversion boxes	29,000,000 L from 224-T: NO_3, Na, PO_4, NH_4, F, SO_4, C_2O_4 TRU levels of contaminated liquid 3,200 g Pu; 0.008 g U-238; 9.7 g Cs-137; 11g Sr-90; 0.008 g Co-60	7.9 m (26 ft)	21 m x 4.3 m (68 ft x 14 ft)	Two wooden cribs connected in series. Cribs received waste once 216-T-6 Crib was full. After 216-T-32 was full, waste was routed to the 216-T-7 Crib. Well 299-W10-3 monitors the site. Dimensions are for bottom of cribs. Low levels of radionuclides are detected from 7.9 to 35 m (26 to 115 ft) bgs.
241-B-361	241-B-361 Settling Tank	Located 600 ft NE of 221-B Bldg., east of Baltimore Ave. and south of the 216-B-5 Reverse Well	1945 to 1947	Received low salt, alkaline radio-active waste from cell washings in the cells 5 and 6 in 221-B and additional waste from 224-B Bldgs. discharged to B-5 Injection Well and B-7A&B Cribs. Waste then rerouted to B-8, B-9	121,000 L of sludge containing mainly $BiPO_4$ with 2.5 kg of Pu (1,060 Ci beta/gamma)	NR	6 m diameter x 5.8 m long (20 ft x 19 ft) Capacity is 136,000 L (36,000 gal)	Cylindrical tank made of reinforced concrete. Tank stopped operating and sludge was sampled in 1976. Tank was stabilized in 1985. Eleven risers are visible above grade. One contains two dip tubes, and another vents the tank (remaining are sealed).

Table 2-3. Summary of Information for the 200-TW-2 Operable Unit. (7 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminants/Volumes Released	Waste Site Depth (bgs)	Waste Site Dimensions	General Description
241-T-361	241-T-361 Settling Tank, 361-T Tank	213 m (700 ft) southwest of the 221-T Building and north of 23rd Street; adjacent to the 216-T-6 Cribs	1944 to 1951	Received liquid effluent and sludge from 221-T and 224-T Buildings. Discharged to 216-T-3 injection well and 216-T-6 Crib. Waste then rerouted to 241-T-152 diversion box	45,600 L (12,000 gal) of sludge + 41,800 L (11,000 gal) of yellow liquid remain after pumping Sludge: 23 µg Pu; 12 µCi/g Sr-90; 67.6 µCi/g Cs-137 Supernate: 3.71 µCi/gal Cs-137; 14.5 mg/gal Pu	9.5 m (31 ft)		Cylindrical tank made of reinforced concrete. Tank stopped operating and sludge was sampled in 1976. Tank stabilized in 1985. Location is indicated by concrete AC-540 markers.
UPR-200-E-7	UPR-200-E-7, UN-200-E-7, Cave-In Near 219-B-9 (241-B-361 Crib)	East side of Baltimore Avenue near the 216-B-9 Crib; south and west of 216-B-5	1954	November 1954, a waste line between 221-B and 241-B-361 tank leaked causing a cave in	Approximately 19,000 L (5,000 gal) of liquid waste. Maximum dose observed was 1.7 rad/hr	NR	2.8 m^2 (30 ft^2)	Due to contradictory information, the exact location of the UPR is unknown.

NR = not recorded

3.0 INITIAL EVALUATION OF REPRESENTATIVE SITES

The purpose of this section is to present the results of previous characterization efforts at the representative sites in the 200-TW-1 and 20-TW-2 OUs to provide a background for understanding the waste sites in these OUs. The contaminant inventory effluent volumes, available soil data, and current understanding of the distribution of contamination are also discussed for the representative sites.

3.1 KNOWN AND SUSPECTED CONTAMINATION

As discussed in Section 2.0, waste sites in these OUs received radionuclides and inorganic chemicals from tank farms and T, B, and U Plants. The estimated inventories of the primary radionuclides and chemicals that were discharged to waste sites in the 200-TW-1 and TW-2 OUs were obtained from the following sources:

- WIDS
- The aggregate area management study (AAMS) reports for the 200 Areas (e.g., DOE-RL 1993a, 1993b)
- *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (DOE-RL 1999)
- *Hanford Tank Chemical and Radionuclide Inventories: HDW Model* (Agnew et al. 1997)
- *An Assessment of the Inventories of the Ferrocyanide Watchlist Tanks* (Borsheim and Simpson 1991)
- *Phase I Remedial Investigation Report for 200-BP-1 Operable Unit* (DOE-RL 1993c)
- *216-B-5 Reverse Well Characterization Study* (Smith 1980)
- *Waste Site Grouping for 200 Areas Soil Investigations* (DOE-RL 1997)
- *Hanford Engineer Works Technical Manual (T/B Plants)* (GE 1944)
- *Uranium Recovery Technical Manual* (GE 1951).

The estimated inventories for the waste sites in these OUs are presented in Tables 3-1 and 3-2.

The waste streams discharged to the 200-TW-1 and 200-TW-2 OU waste sites contained a variety of constituents, such as acids, caustics, salts, and metals. The volume and type of nonradiological contaminants are difficult to quantify because they were not routinely monitored.

3.2 ENVIRONMENTAL MONITORING

Current efforts at the Hanford Site focus on environmental cleanup. Prior to recent cleanup efforts, monitoring was performed across the Hanford Site to measure and evaluate long-term trends in the environmental accumulation of radioactivity. Risks associated with unacceptable levels of contamination were typically addressed by stabilizing (covering with soil, concrete, and/or gravel backfill) the area of concern to minimize impact on human health and the environment.

The accumulation of radioactivity at disposal sites was typically evaluated through sampling and analysis of soil samples. These samples were generally collected directly from the bottom of the receiving sites. The accumulation of radioactivity was the principal focus of monitoring; therefore, samples were routinely collected less than 0.3 m (1 ft) below the bottom of a waste site. Samples were collected on an annual basis; however, the number of samples collected was limited and sample locations were not always documented. Therefore, very little or no information is typically available to evaluate the lateral and vertical extent of contamination in the vadose zone during active periods of discharge. Nonradioactive constituents were not commonly analyzed. Scintillation logging was commonly performed in boreholes adjacent to waste sites. The logs were used to determine the extent of radiological contamination in the subsurface; however, these logs are not quantitative and provide only a general indication of the presence of radiological contamination. Groundwater is monitored for some constituents at these sites through the RCRA requirements and the sitewide groundwater monitoring program.

Currently, environmental monitoring at the Hanford Site consists of effluent monitoring, environmental surveillance, and groundwater and vadose zone monitoring. The environmental surveillance is conducted for the following media:

- Air
- Surface water and sediments
- Drinking water
- Farm and farm products
- Soil and vegetation
- External radiation.

Air, external radiation, soil, and vegetation are routinely evaluated in the 200 Areas as part of the Hanford Site near-facility and environmental monitoring programs. Results of the near-facility and environmental monitoring programs are presented in annual reports. The most recent of these annual reports are the *Hanford Site Near-Facility Environmental Monitoring Data Report for Calendar Year 1998* (PNNL 1999b) and the *Hanford Site Environmental Report for Calendar Year 1998* (PNNL 1999a). The near-facility document focuses on monitoring activities near facilities that have potential to or have discharged, stored, or disposed of radioactive or hazardous materials, including the 200 East and 200 West Areas. The Hanford Site environmental report covers the entire Hanford Site, including those areas not associated with operations (such as the 600 Area). This document examines the resources associated with the Hanford Site, including those media listed above as well as groundwater. Results of these

monitoring efforts for the 200-TW-1 and 200-TW-2 OU waste sites are presented in Section 3.3. The potential impacts of contamination in these waste sites on human health and the environment are discussed in Section 3.4.

Groundwater is also routinely monitored sitewide. More than 600 monitoring wells are sampled annually to characterize groundwater flow; groundwater contamination by metals, radionuclides, and chemical constituents; and the area of contamination. Groundwater remediation and ingestion risk and dose are also assessed. Results of groundwater monitoring and remediation are presented in annual reports, the most recent of which is the *Hanford Site Groundwater Monitoring for Fiscal Year 1999* (PNNL 2000). The groundwater monitoring reports also summarize vadose zone characterization activities conducted on the site through other projects.

3.3 NATURE AND EXTENT OF CONTAMINATION

The following sections describe the nature and extent of contamination at each representative waste site.

3.3.1 216-B-46 Crib

The current understanding of the nature and extent of contamination at the 216-B-46 Crib is summarized from the 200-BP-1 RI Study Report (DOE-RL 1993c). The vadose investigations at the 200-BP-1 OU consisted of sampling three boreholes drilled through the crib (299-E33-299, 299-E33-310, and 299-E33-311). The maximum depth of the investigation in these three boreholes was approximately 11 m (35 ft). Two additional boreholes (299-E33-4 and 299-E33-23) were located adjacent to the crib and provided additional information on the migration of contaminants at this waste site. The total depths in these two boreholes are approximately 70 m (230 ft). The locations of these boreholes are shown in Figure 3-1.

Soil samples were collected for radiological and nonradiological analysis and for analysis of physical properties as part of the 200-BP-1 investigation. Spectral gamma logging data are available for all five boreholes at the site. Soil samples were collected and analyzed for all CERCLA target compound list and target analyte list constituents, major anions, bismuth, cyanide (free, complexed, and total), and major radioisotopes. Bulk density, moisture content, grain size, moisture retention, saturated and unsaturated hydraulic conductivity, specific gravity, calcium carbonate, and porosity data are available from other boreholes in the vicinity of the 216-B-46 Crib (e.g., 31 samples were collected at the 216-B-43 Crib). However, no data were collected at this representative site. Boreholes 299-E33-299, 299-E33-310, and 299-E33-311 were abandoned according to *Washington Administrative Code* (WAC) 173-160 by removing the temporary casing and backfilling the holes with bentonite.

Constituents detected in soil samples at the 216-B-46 Crib (collectively includes 216-B-43 through 216-B-50, 216-B-57, and 216-B-61 [216-B-50, 216-B-57, and 216-B-61 are not in the 200-TW-1 OU]) were subjected to a screening process in the RI report. Constituents were compared to sample blanks, background concentrations, and calculated risk-based screening levels. The goal of this process was to identify contaminants that may pose risk to human health

and the environment. The risk-based screening was applied separately in two different zones. The first zone, 0 to 5 m (0 to 15 ft) bgs, was described as near-surface soils. This zone consisted of stabilized surface soil (trench backfill and gravel near the bottom of the crib). The second zone, defined as deep soils, consisted of soils greater than 5 m (15 ft) bgs. Three soil exposure pathways were used for calculating preliminary risk-based benchmark concentrations: soil ingestion, air inhalation (including inhalation of fugitive dust), and external exposure to radioactivity for both the near-surface soils and deep soils. For groundwater, the only exposure mechanism evaluated was groundwater ingestion.

For near-surface soils, the identified contaminants of potential concern (COPCs) included the following:

- Cesium-137
- Radium-226
- Strontium-90
- Thorium-228
- Total uranium.

For deep soils, the identified COPCs included the following:

- Cadmium
- Nickel
- TBP
- Polychlorinated biphenyls (PCBs)
- Antimony-125
- Cesium-137
- Cobalt-60
- Plutonium-238
- Plutonium-239
- Plutonium-239/240
- Radium-226
- Strontium-90
- Technetium-99
- Thorium-228
- Total uranium.

Although contamination in soils was detected at depths of up to 72 m (236 ft), maximum radionuclide concentrations were generally observed in the 5- to 15-m (15- to 50-ft)-depth range. This depth interval represents the base of the crib gravel and underlying native soil where the observed contaminant distributions are consistent with the relative immobility of many of the radioactive constituents. Below 15 m (50 ft), levels generally declined until a depth of approximately 30 m (100 ft) where concentrations remained uniformly low. Soils above 4 to 5 m (12 to 15 ft) were characterized by relatively low radionuclide levels, as compared to deeper zones. Results of the soil sampling and spectral gamma-ray logging indicate that contamination

is generally confined to the area beneath the cribs and that significant lateral waste migration due to perched groundwater conditions does not appear to have occurred.

For groundwater, the identified COPCs included the following:

- Antimony, arsenic, barium, cadmium, total and free cyanide, complexed cyanide, chromium, copper, lead, manganese, nickel, selenium, silver, thallium, vanadium, fluoride, nitrate, nitrite, sulfate, trichloroethene, 4,4'-DDT, cobalt-60, potassium-40, plutonium-238, radium-226, radium 228, strontium-90, technitium-99, total uranium, and tritium.

Extensive contamination of groundwater near the crib has occurred as a result of Hanford Site operations. This contamination is likely the result of multiple sources located throughout the 200 East and 200 West Areas. While still above regulatory standards, current levels in the groundwater are one or more orders of magnitude less than concentrations that occurred in the early years of Hanford Site operations.

Contaminant plumes that are present throughout the study area at concentrations significantly above background levels, risk-based screening concentrations, or other regulatory criteria were identified for gross beta, total cyanide, cobalt-60, nitrate, technetium-99, and tritium. For the other COPCs in groundwater, the extent of contamination tends to be confined to localized areas and/or is characterized by relatively lower concentrations. Generally, the plumes are centered at well 699-50-53a (located about 1 km [0.6 mi] north of the site where maximum contaminant levels are consistently observed). Well 699-55-57 is also characterized by relatively high concentrations as compared to other monitoring wells throughout the study area. Contaminant plumes near the crib are presented in the RI report (DOE-RL 1993c). Major groundwater plumes in the vicinity of the 200 East Area are shown in Figures 3-2 and 3-3.

Contaminants remaining after risk screening were subject to a baseline and ecological risk assessment (see Section 6.0 of the 200-BP-1 RI report [DOE-RL 1993c]). The baseline risk assessment concludes that a cancer risk of 1×10^{6} is exceeded only under the future industrial scenario for receptors, and only if near-surface soils or deep soils are uncovered, permitting direct contact with contaminants. These risk estimates do not consider the probability that the clean soil cover will be absent or present in the year 2018, or that future workers will excavate deep soils. In addition, because this was a deterministic risk assessment, the uncertainty associated with these risk estimates cannot be quantified. To compensate for the uncertainty associated with input parameters, estimates used to characterize these parameters are often conservatively biased. As a result, the risk estimates provided in these assessments represent a set of assumptions that, as a whole, is extremely unlikely. Use of a more realistic set of assumptions is likely to yield significantly lower risk estimates. The ecological risk assessments suggest a potential impact to loggerhead shrike and burrowing owls from exposure to ionizing radiation. These results suggest that additional studies are necessary to confirm the risk.

3.3.2 216-T-26 Crib

The scintillation probe and spectral gamma-ray system were used to evaluate the nature and extent of contamination beneath the 216-T-26 Crib. Both logging systems were used in borehole

299-W11-70; only the spectral gamma logging results are available from borehole 299-W11-82. Boreholes 299-W11-70 and 299-W11-82 were logged with the spectral gamma-ray system in 1992 and 1995, respectively. Borehole 299-W11-70 was logged with the scintillation probe in 1976. Scintillation results are presented in Fecht et al. (1977). Boreholes near the crib are shown in Figure 3-4.

Borehole 299-W11-70 was logged with the scintillation probe to a depth of approximately 30 m (100 ft) in 1976. The data indicate that radiological contamination is present from the surface to a depth of approximately 29 m (95 ft). The highest contamination was detected in a 24-m (78-ft)-thick zone from approximately 5 to 29 m (17 to 95 ft) bgs. This zone of contamination correlates with the zone of contamination observed in the spectral gamma data collected in 1995. The spectral gamma data indicate that the zone of contamination is 26 m (84 ft) thick, running from 6 to 31 m (19 to 103 ft) bgs. Cesium-137 was the major contributor to the observed contamination; maximum activities exceeded 10,000 pCi/g. Less than 100 pCi/g of cesium was detected between the surface and the top of this highly contaminated zone. Cesium activities generally declined to a depth of 37 m (122 ft) and were not detected beyond this depth. Other gamma-emitting man-made radionuclides detected include cobalt-60 and europium-154. Cobalt-60 was detected from 29 to 31 m (95 to 102 ft) and 38 to 39 m (124 to 128 ft); activities were less than or equal to 0.4 pCi/g. The maximum activity (1.0 pCi/g) of this contaminant was detected near the bottom of the borehole at 43 m (140 ft) bgs. Europium-154 was detected in a 9-m (29-ft)-thick zone, from 21 to 30 m (68 to 97 ft) bgs; activities ranged from less than 1 pCi/g to 4.5 pCi/g.

Borehole 299-W11-82 was logged with the spectral gamma-ray system to a depth of approximately 20 m (65 ft). The data indicated that the first zone of radiological contamination is present from the surface to a depth of approximately 4 m (14 ft). Activities in this zone ranged from 1 pCi/g to 8 pCi/g of cesium-137. Between 4 and 9 m (14 and 30 ft) bgs, cesium activities were less than 1 pCi/g. The major zone of contamination in this borehole was observed at a depth from 9 and 20 m (30 and 65 ft). Cesium-137 is the major contributor to the observed contamination; maximum activities exceeded 1,000 pCi/g. Other contaminants detected in this zone include antimony-125 and europium-154. Cesium activities were highest (900 pCi/g and 1,100 pCi/g) at depths of 10 and 15 m (34 and 49 ft), respectively, and generally decreased with depth from 15 m (49 ft) to the bottom of the borehole. Activities were approximately 30 pCi/g at total depth in this borehole. Within the major zone of contamination, antimony-125 and europium-154 were detected sporadically. The maximum activity for each of these contaminants is 6 pCi/g. The maximum activity of antimony-125 and europium-154 occurred at depths of 14 m and 9 m (45 ft and 31 ft), respectively.

The effluent volume discharged at this site is greater than the soil pore volume. These data indicate that there has been impact to groundwater at this site. The current status of groundwater contamination in the vicinity of the 216-T-26 Crib is described in Barnett and Chou (1998). The report indicates that fluoride, nitrate, carbon tetrachloride, trichloroethylene, technetium-99, iodine-129, and tritium exceed groundwater protection standards/guidelines in the vicinity of the crib. Of these contaminants, only nitrate, iodine-127, and tritium appear to be associated with waste disposal practices at the crib. Major groundwater plumes in the vicinity of the 200 West Area and the 216-T-26 Crib are shown in Figures 3-5 and 3-6.

3.3.3 216-B-5 Reverse Well

Efforts to determine the nature and extent of vadose zone contamination at the 216-B-5 Reverse Well began after the discovery of alpha contamination in the groundwater in the 1940s. Initial assessments to evaluate potential hazards from liquid waste discharged to the ground were developed in 1946 and implemented in 1947 and 1948 (Brown and Ruppert 1948, 1950). Two major objectives of the study were to determine the spatial distribution of radionuclide contamination in the groundwater and to predict the direction of contaminant migration, if any. Eleven wells were drilled near the 216-B-5 Reverse Well; soil and groundwater samples were collected and analyzed for alpha and total beta contamination. No radioactive contaminants were detected in any of the sediment samples collected; however, analysis of groundwater confirmed the presence of beta-gamma and alpha contamination.

The next investigation of the 216-B-5 Reverse Well was conducted in 1979 and 1980. Wells were drilled around the reverse well and soil samples were analyzed to determine the nature and extent of contamination sorbed to sediments in the vadose zone and the groundwater. Wells near the 216-B-5 Reverse Well are shown in Figure 3-7. The data were used to map the distribution of beta-gamma, plutonium-239/240, cesium-137, and strontium-90 contamination. No work was performed to assess the distribution of nonradioactive constituents in the vadose zone. Conclusions of this investigation are presented in Smith (1980) and summarized in this section.

Contaminants near the 216-B-5 Reverse Well were predominantly detected at depths greater than 74 m (243 ft) bgs. The well is perforated from 74 to 92 m (243 to 302 ft). This zone represents points of release for the liquid waste discharged to the ground. This interval also includes the lower 13 m (43 ft) of the vadose zone and the upper portion of the water table. Contaminants detected in the soil samples at this site include cesium-137, plutonium-239/240, strontium-90, and americium-241. The activity of cesium-137 ranged from less than the detection limit to 51,300 pCi/g. The maximum activity of strontium-90, plutonium-239/240, and americium-241 were 60,000 pCi/g, 75,000 pCi/g, and 2,540 pCi/g, respectively. The highest activities were detected in soils in borehole 299-E28-23 located within several meters of the 216-B-5 Reverse Well.

Smith (1980) suggests that the distribution of contamination at this site may be influenced in part by grain size distribution and the position of the water table. The presence of cesium in the silt layer approximately 78 m (256 ft) bgs is indicative of sediment control on the distribution of radionuclides (Smith 1980). Peaks in strontium, cesium, and plutonium activities also correspond to the position of the water table in 1948. The distribution of beta-gamma contamination, cesium-137, plutonium-239/240, and strontium-90 relative to hydrogeologic features in the vicinity of the 216-B-5 Reverse Well are shown in Figures 3-8 through 3-11. Analytical results are presented in Smith (1980).

Chiaramonte (1995) conducted a risk analysis on the major COPCs (i.e., strontium-90, cesium-137, and plutonium-239/240) in the groundwater near the reverse well. For current conditions, a hypothetical industrial groundwater ingestion scenario was evaluated. Both industrial and residential scenarios were assumed for future conditions. Calculations of risks

were based on the highest activities measured from 1993 to 1995. The analysis of existing conditions suggests there is a small area of risk greater than 1×10^{-5} near the reverse well. The maximum incremental lifetime cancer risk (ILCR) (2.1×10^{-3}) was calculated for groundwater in borehole 299-E28-23. Strontium (2,310 pCi/L) was the major contributor (86% of the ILCR). The highest ILCR due to plutonium-239/240 alone is 1.4×10^{-4} based on its maximum activity of 125 pCi/L. The assessment of future conditions indicate that the groundwater plumes are migrating very slowly and confirm the results in DOE-RL (1993c) that indicate that the plumes are not moving or are moving very slowly (Chiaramonte 1995). This is probably due to the very low hydraulic gradients in the area and/or moderate adsorption of the radionuclides in the groundwater system (or precipitation in the case of strontium-90.)

The current status of groundwater contamination in the vicinity of the 216-B-5 Reverse Well is described in Barnett et al. (1999). The report indicates that cesium-137, iodine-129, plutonium-239/240, strontium-90, uranium, and tritium exceed groundwater protection standards/guidelines. Impact to groundwater is attributed to the 216-B-5 Reverse Well and other disposal sites in the 200 East Area. Major groundwater plumes in the vicinity of the 200 East Area and the reverse well are shown in Figures 3-2 and 3-3.

3.3.4 216-B-7A&B Cribs

Spectral gamma-ray and scintillation geophysical log data from boreholes 299-E33-58, 299-E33-59, and 299-E33-75 were evaluated to assess the nature and extent of contamination at the 216-B-7A&B Cribs. Scintillation log profiles provide a qualitative means of evaluating the extent of radiological contamination in the subsurface and are presented in Fecht et al. (1977). Boreholes were also logged with the high-purity germanium (HPGe) spectral gamma-ray system to assess the type and current extent of contamination in the subsurface in 1992. Boreholes near the cribs are shown in Figure 3-12. Sediment data are not available to evaluate the nature and extent of contamination at this site.

Cesium-137 was identified in borehole 299-E33-58 with the spectral gamma-ray tool from the surface to a depth of 31 m (101 ft). This is the maximum vertical extent of contamination detected in the vadose zone beneath this site. Cesium-137 activity ranged from 1 to 22 pCi/g from depths of 0 to 3 m (0 to 10 ft). The contamination in this upper zone is likely associated with the consolidation of contaminated soil from UPR-200-E-144 onto the crib area. Contaminated soil from the UPR-200-E-144 was placed over the cribs in 1992 and covered by 0.6 m (2 ft) of clean topsoil. Less than 1 pCi/g of cesium-137 was detected between 3 and 6 m (10 and 20 ft) bgs (WIDS).

Most of the cesium-137 detected with the spectral gamma-ray system in borehole 299-E33-58 was detected between 6 and 22 m (20 and 71 ft) bgs. The top of this highly contaminated zone is approximately 2 m (6 ft) below the bottom of the crib. Results from spectral gamma-ray logging correlate closely with the scintillation profile. Scintillation profiles in Fecht et al. (1977) indicated the highest contamination was detected from 4.6 to 22 m (15 ft to 72 ft) bgs. A comparison of two log profiles over a 16-year period suggests that the highly contaminated portion of the cesium plume is not migrating in the subsurface. The maximum activity of cesium-137 exceeded 4,500 pCi/g at approximately 10 m (33 ft) bgs. Profiles at this site also

indicate that activities generally decreased with depth below 22 to 31 m (71 to 101 ft). Cesium activities were not detected below 31 m (101 ft) bgs. No other man-made gamma-emitting radionuclides were detected in the borehole.

Scintillation profiles in boreholes 299-E33-59 and 299-E33-75 are similar to the profile in borehole 299-E33-58. The major zone of contamination in these two boreholes, based on 1976 scintillation log profiles, ranges between 4.6 and 15 m (15 and 50 ft) bgs. These profiles compare consistently with spectral data and confirm the distribution of a highly contaminated zone in the subsurface. Little or no contamination was detected at depth in borehole 299-E33-18 in 1992. This borehole is located stratigraphically upslope of the cribs in relation to horizons (mainly the upper gravel sequence of the Hanford formation) that would impede vertical transport of contaminants. However, Barnett et al. (1999) indicate that uranium-238 was detected in borehole 299-E33-18 with the spectral gamma-ray system from 71 to 76 m (233 to 250 ft) in 1997. Activities in this well increased from 0 pCi/g in 1992 to 400 pCi/g in 1997.

The distribution of contamination in boreholes surrounding the 216-B-7A&B Cribs indicates that effluent and contaminants have migrated beneath and laterally from the cribs. Contaminant migration is mainly vertical; however, conclusions presented in Fecht et al. (1977) suggest that contamination extends at least 24 m (80 ft) to the north of borehole 299-E33-75. Recent interpretations of the upper surface of the sand-dominated sequence (Stephens & Associates 1998) suggest there may be more of a northeast component of contaminant migration. The top of the sand-dominated sequence slopes to the northeast near the cribs and appears to be the dominant subsurface feature controlling lateral movement of contaminants from the cribs. The geology of the site does not appear to support transport of contaminants north to borehole 299-E33-75, unless there is a preferential pathway within the gravel-dominated sequence of the Hanford formation. The highly contaminated zone in borehole 299-E33-75 is about 5 to 13 m (16 to 43 ft) bgs; this upper surface is stratigraphically at an elevation nearly equal to the bottom of the cribs. This suggests that there may be a secondary or different source for the contamination in borehole 299-E33-75.

Soil column pore volume calculations and the volume of liquid discharged to the 216-B-7A&B Cribs were presented in the waste site grouping report (DOE-RL 1997). These data were presented to assess potential impacts on groundwater. Where effluent volumes exceeds the soil column pore volume, there is a higher potential to impact groundwater. The effluent volume discharged at this site is 75 times greater than the soil pore volumes. The current status of groundwater contamination in the vicinity of the 216-B-7A&B Cribs is described in Barnett et al. (1999). The report indicates that nitrate, uranium, technetium-99, iodine-129, and tritium exceed groundwater protection standards/guidelines. Impact to groundwater is attributed to the 216-B-7A&B Cribs, as well as other waste sites in the 200 East Area. Major groundwater plumes in the vicinity of the 200 East Area and the cribs are shown in Figures 3-2 and 3-3.

3.3.5 216-B-38 Trench

The nature and extent of contamination at the 216-B-38 Trench was assessed by evaluating spectral gamma and neutron-moisture geophysical log data from boreholes 299-E33-289 and 299-E33-290. These boreholes are located within 4.6 m (15 ft) of the trench (Figure 3-13). The

boreholes were logged on June 21, 1999 to a total depth of 16 m (52 ft). No sampling data are available to evaluate the nature and extent of contamination at these locations.

Cesium-137 was the only gamma-emitting man-made radionuclide identified in borehole 299-E33-289. The contaminant was identified from 1 to 2 m (2 to 5 ft) and 4.6 to 15 m (15 to 49 ft). From 0 to 2 m (0 to 5 ft), the activity of cesium ranged from 4 to 49 pCi/g; cesium was not detected from 2 to 4 m (5 to 14 ft) bgs. This contaminant was next detected at 4.6 m (15 ft) bgs at an activity of 4 pCi/g and reached a maximum activity of 55,000 pCi/g at 5 m (17 ft). The count rate limits of the instrument were exceeded from approximately 5 to 6 m (16 to 19 ft) bgs, although the instrument did not saturate. This is an indicator that the true activities in this zone are higher than the activities recorded. The highest zone of moisture in this borehole is at depths between 4.6 and 8 m (15 and 25 ft) bgs and ranges between 10% and 25%. Elevated moisture content in this borehole is correlative to the highest zones of contamination. Activities generally declined from greater than 12,000 pCi/g to about 1,000 pCi/g at depths between 6 to 9 m (20 to 29 ft). Cesium-137 activities below 9 m (29 ft) bgs ranged between 10 and 50 pCi/g.

Cesium-137 was the only gamma-emitting man-made radionuclide identified in borehole 299-E33-290. Cesium-137 was identified from 6 to 15 m (19 to 49 ft) in 299-E33-290. The highest activities were detected at depths between 6 to 9 m (20 to 30 ft) and ranged from 1,000 to 75,000 pCi/g. The maximum concentration of cesium-137 occurred at a depth of 8 m (25 ft) bgs. The count rate limits were exceeded from approximately 7 to 9 m (22 to 30 ft), although the instrument did not saturate. As stated previously, when count rates limits are exceeded, the true activities are higher than the activities recorded. This zone of high contamination correlates to a thin zone of higher moisture (20% to 30%) at 6 to 7 m (20 to 24 ft) bgs. Cesium-137 activities at depths greater than 9 m (30 ft) bgs ranged between 500 and 5,000 pCi/g and increased toward the bottom of the borehole.

Soil column pore volumes beneath the 216-B-38 Trench are estimated to be greater than the volume of effluent discharged to the ground at this site (DOE-RL 1997). This suggests that there was no impact to groundwater during the active operation of this site. Groundwater plumes in the vicinity of this site are described in Barnett et al. (1999). The report indicates that nitrate, technetium-99, iodine-129, and tritium exceed groundwater protection standards/guidelines in the vicinity of the trench (Figures 3-2 and 3-3). Current impacts of waste disposal practices at this trench on groundwater have not been determined.

3.3.6 Environmental Information

A summary of ecological and cultural resources for the 200 Areas is provided in Appendix F and Sections 8.0 and 9.0 of the Implementation Plan (DOE-RL 1999). Information on these resources is also included in the annual environmental monitoring reports. This section of the work plan presents available ecological sampling and monitoring data in the vicinity of the 200-TW-1 and 200-TW-2 OU waste sites. Several sources of data were consulted and researched to provide this summary, including the following:

- *Historical Records of Radioactive Contamination in Biota at the 200 Areas of the Hanford Site* (WHC 1994b)
- *Hanford Site Near-Facility Environmental Monitoring Data Report for Calendar Year 1998* (PNNL 1999b) (and previous year annual reports)
- *Ecological Sampling at Four Waste Sites in the 200 Areas* (Mitchell and Weiss 1995)
- *Phase I Remedial Investigation Report for 200-BP-1 Operable Unit* (DOE-RL 1993c).

Eighty-five environmental monitoring records of wildlife and vegetation at the 200 East and 200 West Areas since 1965 were reviewed and summarized in WHC (1994b). The report indicates that several areas in the vicinity of the 200-TW-1 and 200-TW-2 OU waste sites have been sampled over the years. About 4,500 individual cases of monitoring for radionuclide uptake or transport in biota in the 200 Area environs were included in the documents reviewed in WHC (1994b). Approximately 1,900 (42%) of these biota had radionuclide concentrations in excess of 10 pCi/g. These radionuclide transport or uptake cases were distributed among 45 species of animals (mostly small mammals and feces) and 30 species of vegetation. However, the document does not provide sufficient information to associate the data with actual waste sites. The animal species most commonly associated with the radiological contamination were the house mouse and the deer mouse. The vegetative species most commonly associated with the contamination was the Russian thistle. The largest numbers and levels of radionuclide uptake or transport occurred at several sites in the vicinity of the 200-TW-1 and 200-TW-2 OU waste sites (and at other sites not related to these OUs), including the 216-B-3 Ditches, the 216-BC Cribs, the 241-B Tank Farm, and the 241-BX/BY Tank Farms. Much of this information was collected prior to stabilization activities at the individual waste sites. Noticeable improvements in reducing the uptake and transport of radionuclide contaminants by biota were observed in areas where interim stabilization activities have taken place (WHC 1994b).

Several samples were collected on or adjacent to representative waste sites in the 200-TW-1 and 200-TW-2 OUs. Soil and vegetation data samples were collected from stations D012/V012 through D018/V018, D035/V035, and D036/V036 at the T, TY, and TX Tank Farms. Stations D035/V035 and D036/V036 are located near the 216-T-26 Crib. Samples were also collected at D053/V053 and D054/V054 (near the 216-B-46 Crib), D055/V055 (near the 216-B-38 Trench), D056/V056 (near the 216-B-7A&B Cribs), and D057/V057 and D058/V058 (in the vicinity of the 241-B Tank Farm). The locations of these samples are included the *Hanford Site Near-Facility Environmental Monitoring Data Report for Calendar Year 1998* (PNNL 1999b). The data are presented in this report in Table 3-3.

In 1993 and 1994, Mitchell and Weiss (1995) summarized a sampling effort to collect ecological samples at four sites within the 200 Areas, including the 216-B-3 Pond and the 216-T-4 Ditch. Control samples were collected from a site on the Saddle Mountain Wildlife Refuge. Sampling locations are shown in Mitchell and Weiss (1995). Soil, vegetation, small mammal, and insect samples were collected and analyzed for EPA's target analyte list constituents, strontium-90, total uranium, and gamma-emitting radionuclides using gamma spectroscopy. Soil and vegetation samples were also analyzed for technetium-99. A summary of the data results is

presented in Table 3-4. While the sites sampled are not within the 200-TW-1 and 200-TW-2 OUs, they are in the vicinity of the OU sites. The basis of the sampling strategy was to select some worst-case sites to focus future biota sampling activities.

Vegetation analysis included two cheatgrass and two Russian thistle samples at the 216-U-11 Ditch. Strontium-90 was detected in one cheatgrass sample and both Russian thistle samples. Copper and zinc were detected in one cheatgrass sample and both Russian thistle samples. However, copper was also present in the associated sample blank. The only analytes detected in small mammal (pocket mouse) samples were strontium-90 (one out of four samples) and selenium (three out of four samples, but also detected in the associate sample blank). Strontium-90 was the only analyte detected in the composite insect sample. The following constituents were undetected in all samples: technetium-99, cobalt-60, cesium-137, cadmium, mercury, selenium, silver, and cyanide.

Mitchell and Weiss (1995) concluded that Russian thistle is the preferred vegetative indicator for radionuclide and metal uptake, and pocket mice are preferred mammalian indicators of contaminant uptake at terrestrial sites.

An ecological risk assessment was performed as part of the 200-BP-1 RI/FS process to evaluate the impact of near-surface soil contaminants on six indicator species (Great Basin pocket mouse, jackrabbit, Swainson's hawk, loggerhead shrike, burrowing owl, and coyote). The risk assessment was based on limited data and was considered to have a high degree of uncertainty. The results indicated that the pocket mouse, jackrabbit, loggerhead shrike, and burrowing owl could be adversely impacted if exposure to the contaminated soils is allowed to occur (DOE-RL 1993c).

Although not identified as representative waste sites, the 200 B/C Crib area waste sites are of interest because of past biological transport of contaminants. Intermittent surveys of the 200 B/C Crib area and surrounding land conducted between 1958 and 1998 found radionuclide-contaminated rabbit and coyote feces south, east, and west of the crib site. An investigation conducted in the 1960s indicated that animals had intruded into the crib soils and exposed radionuclide-bearing salts that other animals may have subsequently used as a salt lick. Vegetation has also been shown to have taken up radionuclides through root systems; dead plants have been windblown, scattering particulate contamination over the surrounding landscape. Maxfield (1974) determined that contamination was no longer being spread. Subsequent aerial surveys support this conclusion; neither the shape nor location of contaminant concentration contours measured through aerial surveys has changed appreciably in the last 20 years, except for a decrease in concentration that is attributed to radioactive decay.

A zone of approximately 10 km^2 (4 mi^2) was classified as the 200 B/C Control Area in 1964 to limit access to the crib site and the known contaminated areas. Approximately 45,873 m^3 (60,000 yd^3) of soil was added to the surface of some of the trenches in 1969 to bring the ground surface to a level approximately 3 m (10 ft) above the bottom of most of the cribs and trenches. This addition halted intrusion of deep-rooted plants into the contaminated zone. Gravel and/or asphalt topping was added to several trenches to inhibit animal intrusion. Previously deposited animal feces remain in the surrounding area.

Site assessments recognized rush and grasses as essential for reducing resuspension of soil by wind, which could spread contamination over wide areas of the site. In 1973, 16.9 km (10.5 mi) of roads were built as fire breaks within the controlled area and to provide easy access for fire-fighting equipment if a major fire threatened to devastate this surface covering. Studies conducted at that time indicated that the majority of the contamination was concentrated in approximately 226 hectares (560 acres) south and east of the crib area; surveys in this area showed surface contamination levels of 1 to 10 $\mu Ci/m^2$. An additional 809 hectares (2,000 acres) contained concentrations generally less than 1 $\mu Ci/m^2$ (Maxfield 1974). The total contamination on the ground surface and to a depth of 2.5 cm was estimated in 1974 at 40 Ci: 32 Ci of strontium-90 and 8 Ci of cesium-137 (Maxfield 1974). This report concluded that there was "an extremely low probability of any detectable injury" as a result of entry into this zone (Maxfield 1974).

Aerial surveys flown in 1973, 1978, 1988, and 1996 provide contours for levels of cesium-137 and man-made isotopes detected in flights over the 200 B/C Area. Data from these years were used to make an assessment of migration of contaminants over time. The isopleth contours indicate that generally the same areas of radionuclide contamination were observed in each survey. A comparison of the mapped cesium-137 results indicates that the areas of contamination have grown smaller over the years. This decrease is most likely a result of radioactive decay and downward movement of radionuclides associated with rain and snow melt. The data verify, however, that ongoing distribution of contaminants from the cribs is not occurring.

In 1996, an off-normal report was issued that indicated the presence of contamination outside the 10-km^2 (4-mi^2) controlled area. Total contamination at levels up to 30,000 dpm beta/gamma was found in eight areas. The contamination was believed to be the product of legacy waste from the 200 B/C Cribs that migrated to adjacent areas south of the crib area through animal and vegetation intrusion. The posted area was increased to approximately 31 km^2 (12 mi^2) total, with the southern boundary being the Army Loop Road. This southern boundary was chosen mainly because of the convenient access provided for further monitoring and to control access by authorized site personnel.

In 1997 and 1998, surveys were made of limited areas with both a tractor-mounted beta/gamma detector system and hand-carried Geiger-Mueller probes. Areas directly over the surface of the crib area and along two firebreak roads were surveyed. Measurable low-level contamination was found to the west and south of the crib area and also to the east and south of the crib area. Two additional spots of total contamination estimated to be 1,000 to 10,000 cpm were found and decontaminated on the northern bank of the Army Loop Road, the southern boundary of the posted area.

Laboratory analyses were performed in 1974 on several types of vegetation from the crib site (Maxfield 1974). Radionuclides found in these samples included cesium-137 at concentrations ranging from 1.3 to 8.1 pCi/g and strontium-90 concentrations ranging from 3 to 244 pCi/g. Among the varieties of vegetation sampled, only cheatgrass was reported to have an activity less than 1 pCi/g. No data were reported for nonradionuclide species that may have been evaluated in the vegetation.

The concentrations of cesium-137 and strontium-90 in a sample of soil from near one of the 200 B/C Crib towers were found to be approximately the same as background; this location is assumed to be one of the air monitoring towers constructed near the cribs in the mid-1970s (Maxfield 1974). No alpha activity was detected in these samples. Activity levels of other isotopes were about a factor of 10 less than the cesium and strontium activity.

Radiological surveys and soil sampling were conducted in 1999 to evaluate the potential to repost areas of the soil contamination area associated with the 200 B/C Cribs area. Activities included (1) radiological surveys along radial transects emanating from the center of the isopleth of greatest cesium-137 concentration out to the surface contamination area boundary using a sodium iodide detector, (2) measurement of transferable contamination on the shoes of a radiological technician, and (3) sampling and analysis of the cryptogamic layer (layer of surface soil comprised mostly of mosses, lichens, and algae) and underlying layers. The transect surveys were used to identify sampling locations for the transferability and cryptogamic studies. The results of the transferability study indicated that both areas inside and outside the firebreak roads showed levels of transferable contamination that would disallow reposting. For the areas outside the firebreak roads, few readings exceeded 2,000 cpm. An informal estimate of dose for workers or visitors was less than 1 mrem/yr. Comparisons between the cryptogam and underlying soils showed no significant difference between concentrations in these layers for strontium-90 and cesium-137.

3.4 POTENTIAL IMPACTS TO HUMAN HEALTH AND THE ENVIRONMENT

Preliminary conceptual contaminant distribution models were developed for the 200-TW-1 and 200-TW-2 OUs in the waste grouping report (DOE-RL 1997). The preliminary models are updated with conceptual contaminant distribution models of representative sites in this section. The revised conceptual contaminant distribution models are based on physical conditions and the nature and extent of contamination at representative sites. Conceptual contaminant distribution models are shown in Figures 3-14 through 3-18.

Information pertaining to contaminant sources, release mechanisms, transport media, exposure route, and receptors have also been incorporated into the discussion of the conceptual contaminant distribution models in this section. The conceptual exposure model is included to develop an understanding of potential risks and exposure pathways (Figure 3-19). This information will support an evaluation of potential human health and environmental risk.

Waste streams in the 200-TW-1 and 200-TW-2 OUs consisted of highly contaminated effluent. The waste streams are characterized by significant concentration of both radionuclides and inorganic chemicals (DOE-RL 1999). The primary sources of contamination at waste sites in these groups were generated at chemical processing plants (i.e., T, B, and U Plants) in the 200 Areas. The contaminated liquid wastes from these facilities were transferred to and managed within the B, BX, BY, T, TX, and TY SST farms. Effluent from the SST farm system was discharged to the soil column in trenches, cribs, and reverse wells.

Releases to the environment from primary sources have produced secondary contaminant sources. These secondary sources consist of contaminated surface soils, subsurface soils, and groundwater beneath waste sites. Releases from secondary sources can also impact the environment by infiltration, resuspension of contaminated soil, volatilization, biotic uptake, leaching, and external radiation. When waste sites were receiving effluent, the dominant mechanism of contaminant transport was infiltration. After this practice ceased, liquids continued to move through the soil column by gravity drainage for an undetermined period of time. Currently, the dominant mechanism of contaminant transport is assumed to be residual moisture from the effluents and natural recharge.

The following statements are general conclusions regarding the conceptual contaminant distribution model for these waste groups.

- Effluent discharged to waste sites in these OUs consisted of high salt, neutral/basic, and low organic waste with high levels of fission products. COPCs include cesium, plutonium, strontium, technetium, and uranium.

- Waste sites generally received small quantities of effluent. Of 64 waste sites in the 2 OUs, effluent volumes exceeded soil pore volumes at only 8 sites. Therefore, the wetting front and contaminants at most sites should be located in the vadose zone high above the water table. Soil pore volumes were exceeded at three of the representative sites (216-B-46, 216-T-26, and 216-B-7A&B). Contaminants at the 216-B-5 Reverse Well were injected directly into the aquifer and vadose zone just above the aquifer.

- Effluent and mobile contaminants migrated vertically beneath the waste sites after release. Lateral spreading of liquids and contaminants may have occurred at the sandy sequence of the Hanford formation and the Plio-Pleistocene unit/early Palouse soil. At waste sites where effluent volumes exceed soil pore volumes, and where liquid waste was injected directly into or near the aquifer, groundwater is assumed to have been impacted.

- Contaminants such as cesium and plutonium normally adsorb strongly onto Hanford site sediments because they have large distribution coefficients (K_d). These immobile contaminants should be detected near points of release in the vadose zone because of their large K_d. Contaminants with low K_ds (e.g., nitrite and tritium) are not readily adsorbed on soil particles and migrate to greater depth within the vadose zone. For example, cesium-137 (K_d > 2,000 mL/g) may be concentrated near the point of release with strontium (K_d = 0.4 to 50 mL/g) and uranium (K_d = 1 mL/g) present at greater depths. Contaminants with K_ds equal to 0, such as tritium, will migrate with the extent of the wetting moisture front. However, enhanced mobility has been observed in some tank waste contaminated zones. A prime contributor to enhanced cesium mobility may be the competition for adsorption sites between the cesium-137 and the high concentration of sodium in tank fluids. Serne et al. (1998) reported cesium K_ds in the range of 6 to 10 mL/g for bismuth phosphate tank waste and 2 to 6 mL/g for simulated tank T-106 tank waste. These lower K_ds suggest that cesium-137 should be detected a greater depths in the subsurface in comparison to other waste group OUs.

- Contaminant data from waste sites in this group support the assertion of enhanced mobility for cesium-137. The available data suggest that the zone of greatest contamination generally is less than 31 m (103 ft) bgs at these waste sites. Most of the activity is due to cesium-137.

- Contaminant concentrations generally decrease with depth; however, elevated concentrations may be associated with finer grained faces.

Waste sites in the 200-TW-1 and 200-TW-2 OUs no longer receive effluent. Sites in these OUs have generally been stabilized and covered with clean soil. With the cessation of artificial recharge, the downward flux of moisture through the vadose zone has decreased. Residual moisture should continue to decrease in the vadose zone over time and equilibrate with the natural recharge rate, thus reducing the potential for impacts to groundwater.

Potential receptors (human and ecological) may be exposed to the affected media through several exposure pathways, including inhalation, ingestion, and direct exposure to external gamma radiation. Potential human receptors include current and future site workers and visitors (occasional users). Potential ecological receptors include terrestrial plants and animals. The preliminary conceptual exposure model for the 200-TW-1 and TW-2 OUs is shown in Figure 3-19.

Future impacts to humans are largely dependent on the land use. The type of future land use is not certain at this time, but some type of restricted land use for the 200 Areas is favored by the DOE, EPA, and Ecology (Tri-Parties). All the sites within the 200-TW-1 and 200-TW-2 OUs are located within the exclusive land-use boundary identified in the *Final Comprehensive Land-Use Plan Environmental Impact Statement* (DOE 1999a) and the ROD (DOE 1999b).

3.5 DEVELOPMENT OF CONTAMINANTS OF CONCERN

The development of the list of COPCs and refinement to the list of contaminants of concern (COCs) for each of these OUs were main objectives of the DQO process. The preliminary list of COPCs for each OU included the complete set of contaminants that were potentially discharged to these waste groups from facilities discussed in Section 2.2. This master list of COPCs was generated by process information gathered and evaluated against a set of exclusion criteria to enable the development of a final COC list. Chemical characteristics such as toxicity, persistence, and chemical behavior in the environment were considered. The criteria for exclusion of certain constituents, as detailed in the DQO report (BHI 2000), are as follows:

- Short-lived radionuclides (half-lives of less than 3 years)

- Radionuclides that constitute less than 1% of the fission product inventory. Historical sampling also indicates that these radionuclides have not been detected in the environment

- Naturally occurring isotopes that were not created during Hanford Site operations

- Constituents with atomic mass greater than 242 that represent less than 1% of the actinide activities
- Progeny radionuclides that build insignificant activities within 50 years
- Chemicals that have no known carcinogenic or toxic effect
- Constituents that have been diluted, neutralized, and/or decomposed by high volumes of water and/or the presence of acids and bases (i.e., organic chemicals)
- Chemicals that are not persistent in the environment (i.e., organic chemicals)
- Potentially hazardous or toxic substances that are analyzed in the general suite of metals analysis performed.

The exclusion process resulted in a final list of COCs for each OU, which are presented in Tables 3-5 and 3-6. The preliminary list of COPCs, the excluded analytes, and the rationale for exclusion are presented in the DQO summary report (BHI 2000).

Figure 3-1. 216-B-46 Crib Borehole Location Map.

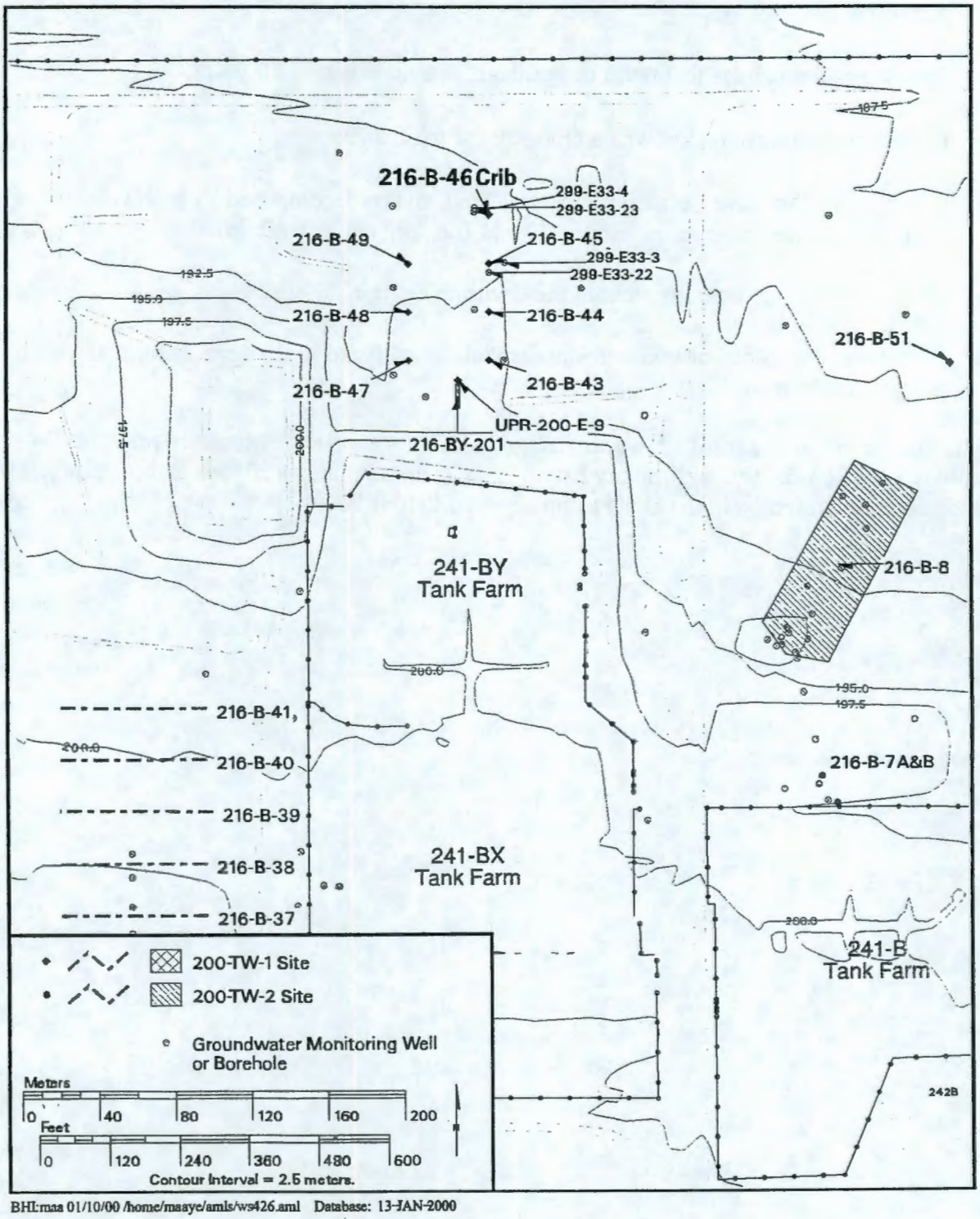
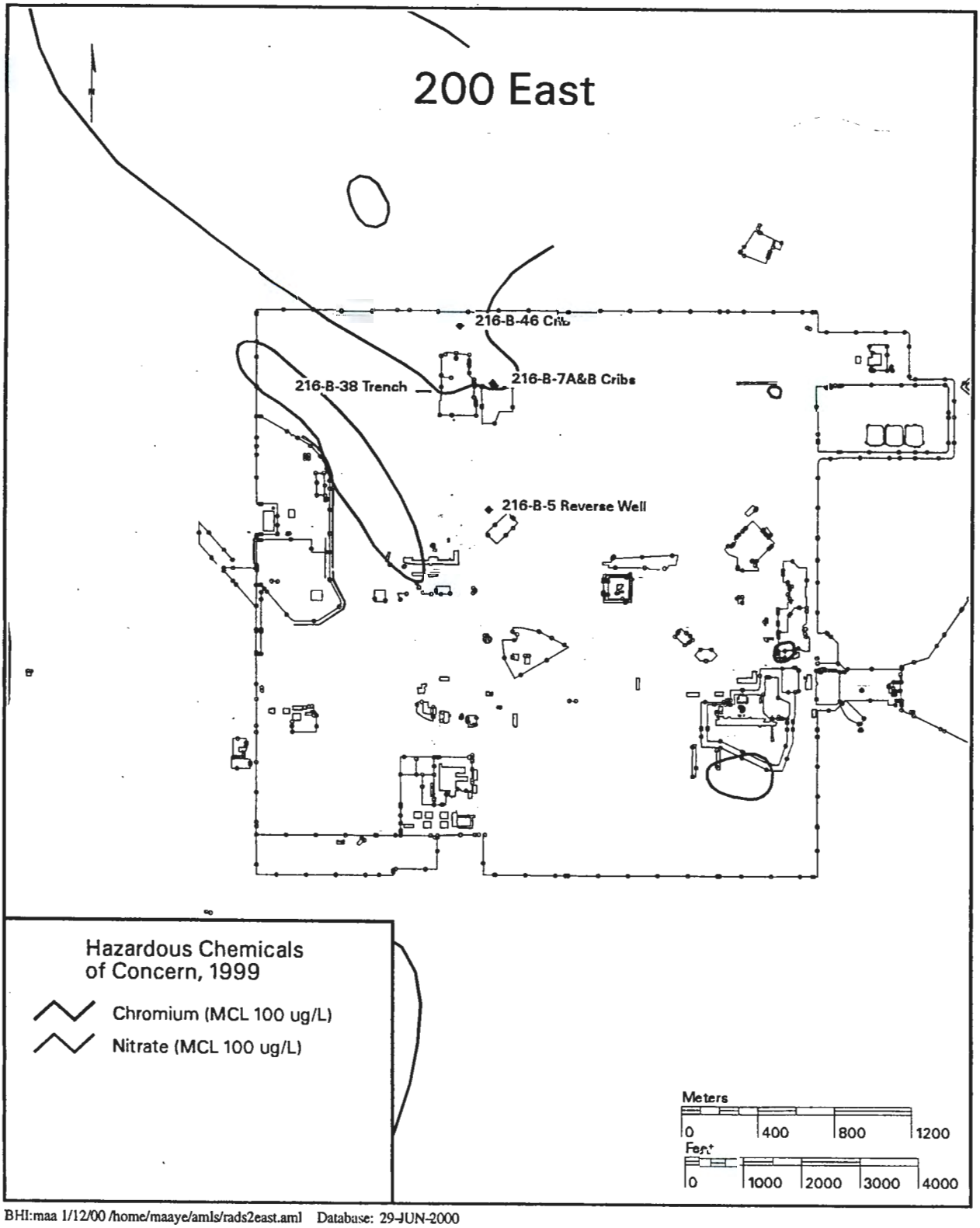
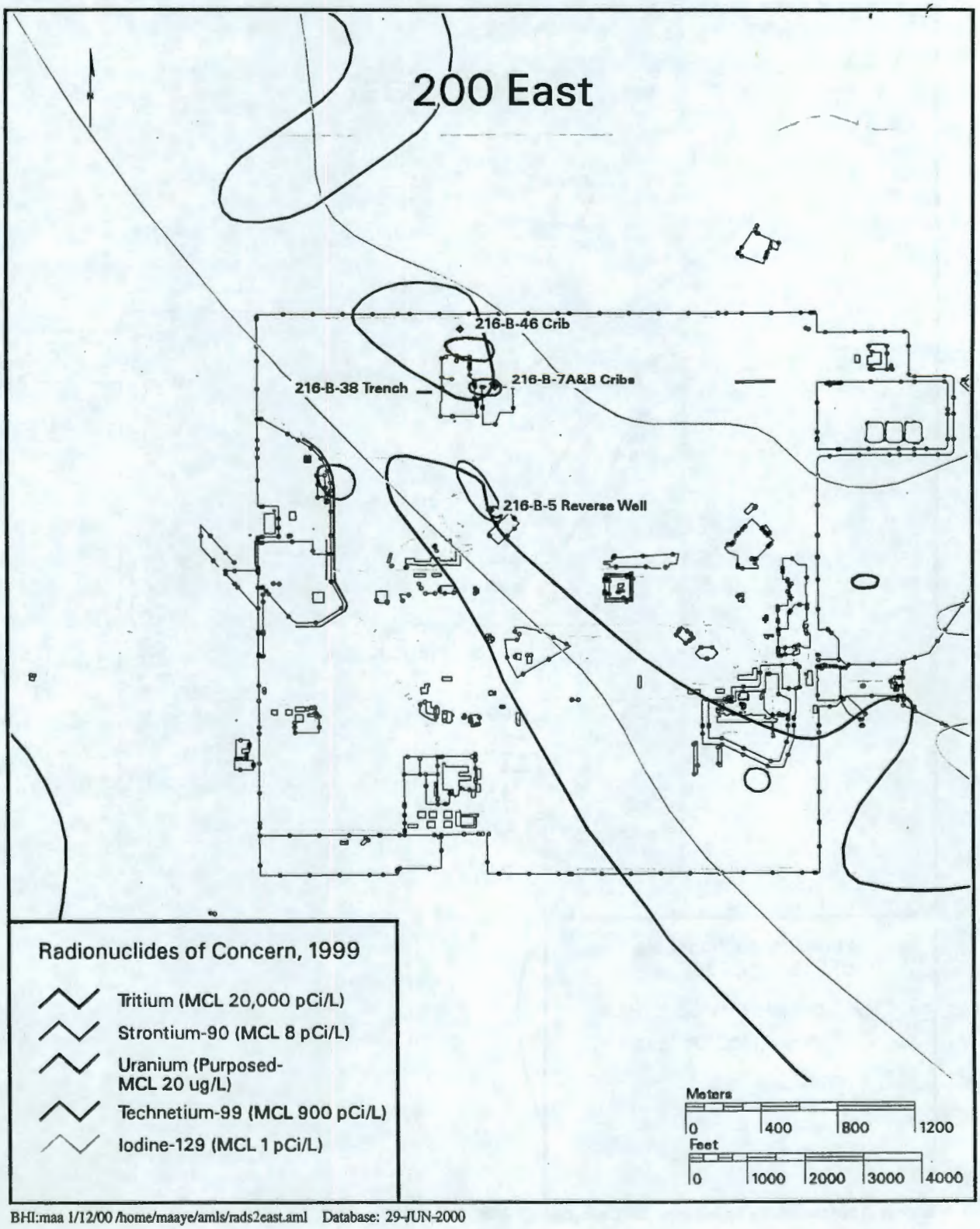


Figure 3-2. Major Nonradiological Groundwater Plumes in the Vicinity of the 200 East Area (Modified from PNNL 2000).



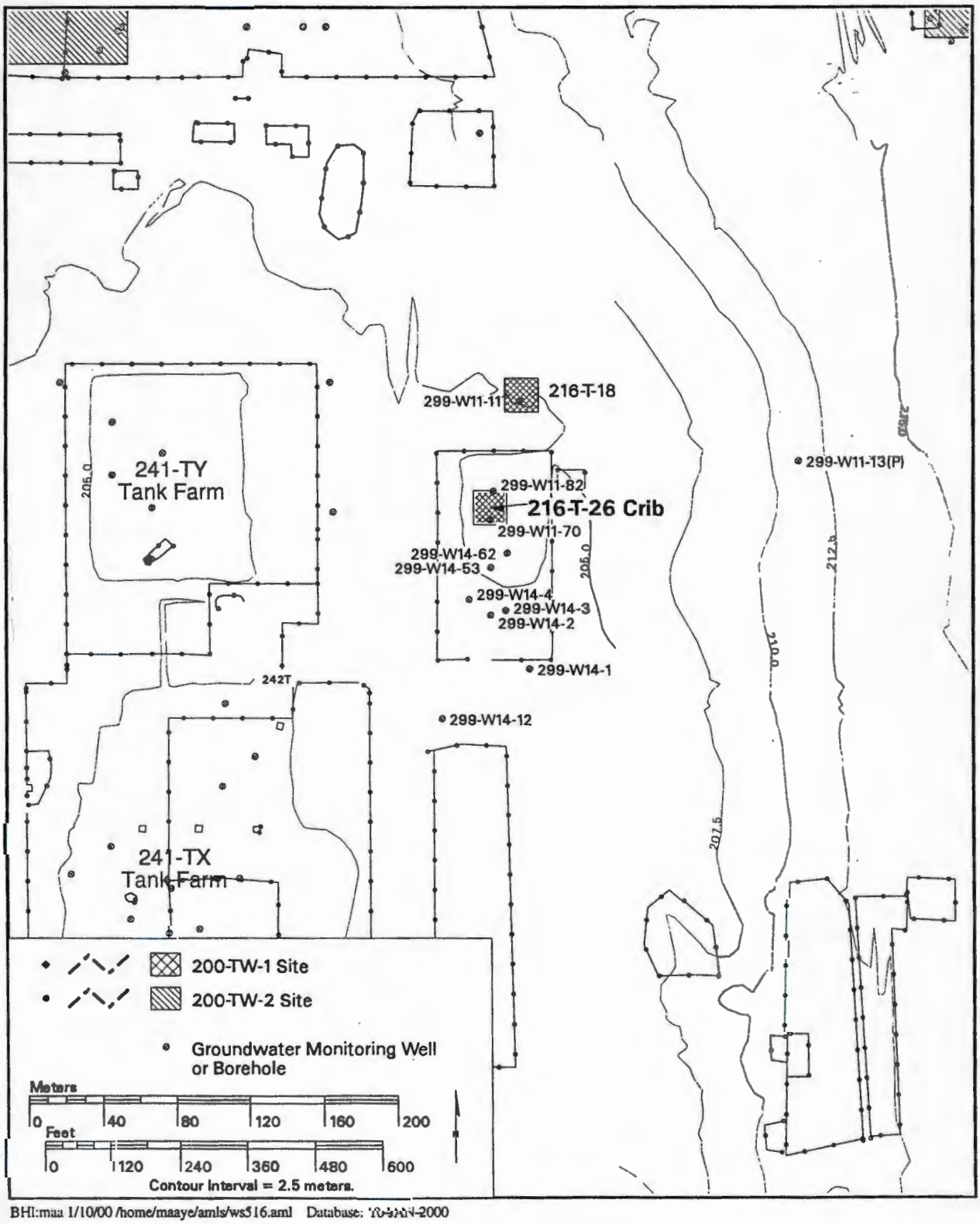
BHI:maa 1/12/00 /home/maaye/amls/rads2east.aml Database: 29-JUN-2000

Figure 3-3. Major Radiological Groundwater Plumes in the Vicinity of the 200 West Area (Modified from PNNL 2000).



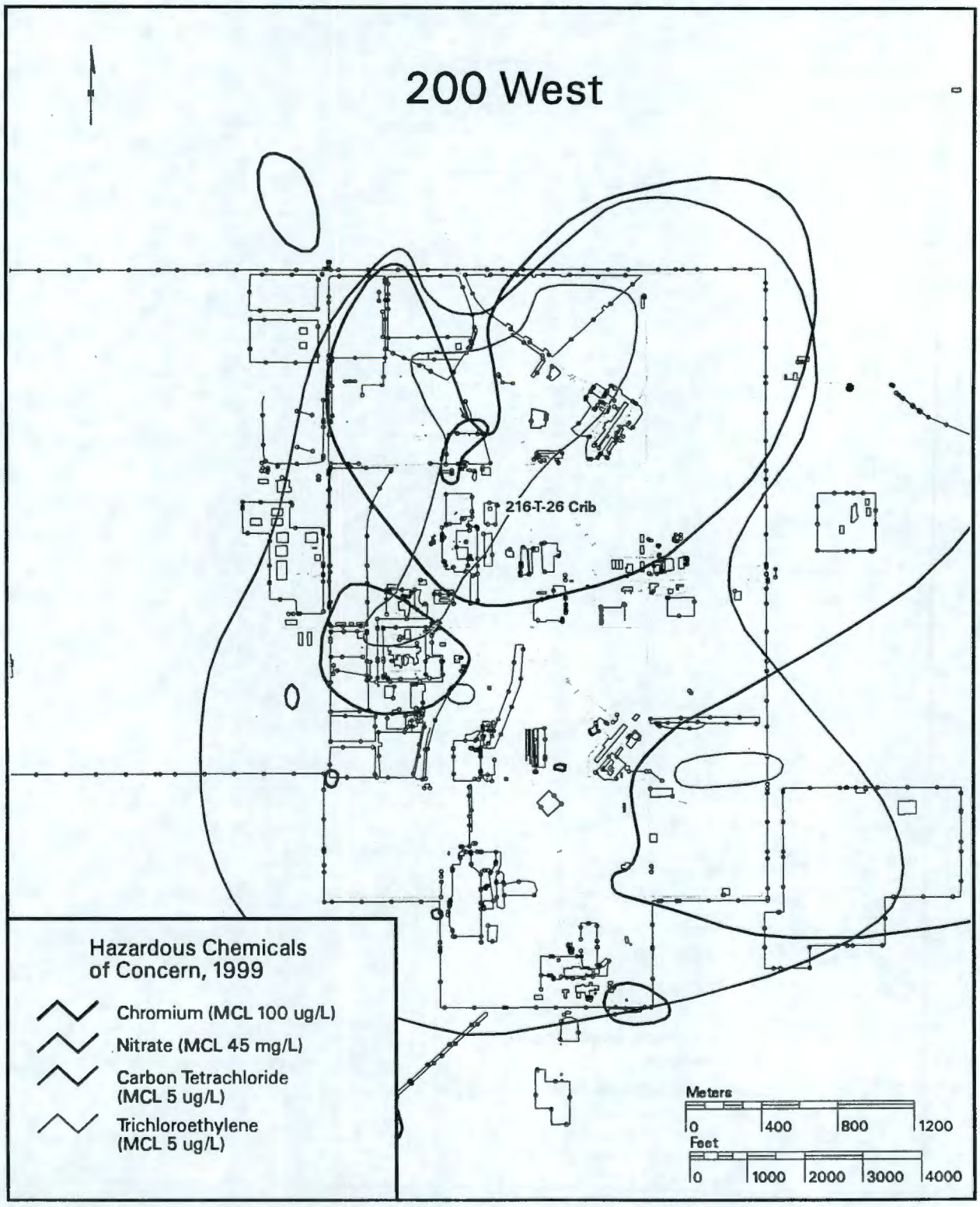
BHI:maa 1/12/00 /home/maaye/amls/rads2east.aml Database: 29-JUN-2000

Figure 3-4. 216-T-26 Crib Borehole Location Map.



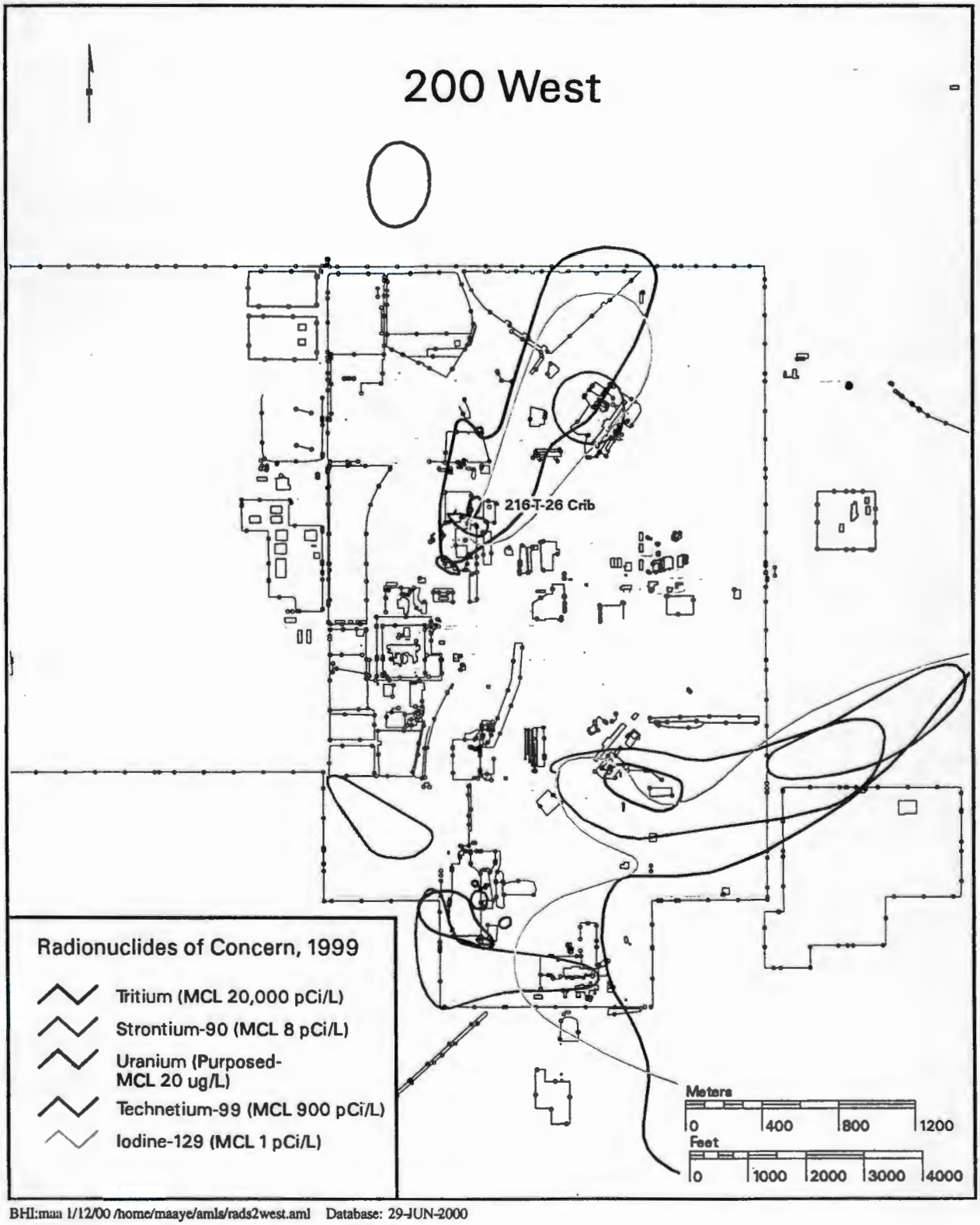
BHI:maa 1/10/00 /home/maaye/amls/ws516.aml Database: RDSAN-2000

Figure 3-5. Major Nonradiological Groundwater Plumes in the Vicinity of the 200 West Area (Modified from PNNL 2000).



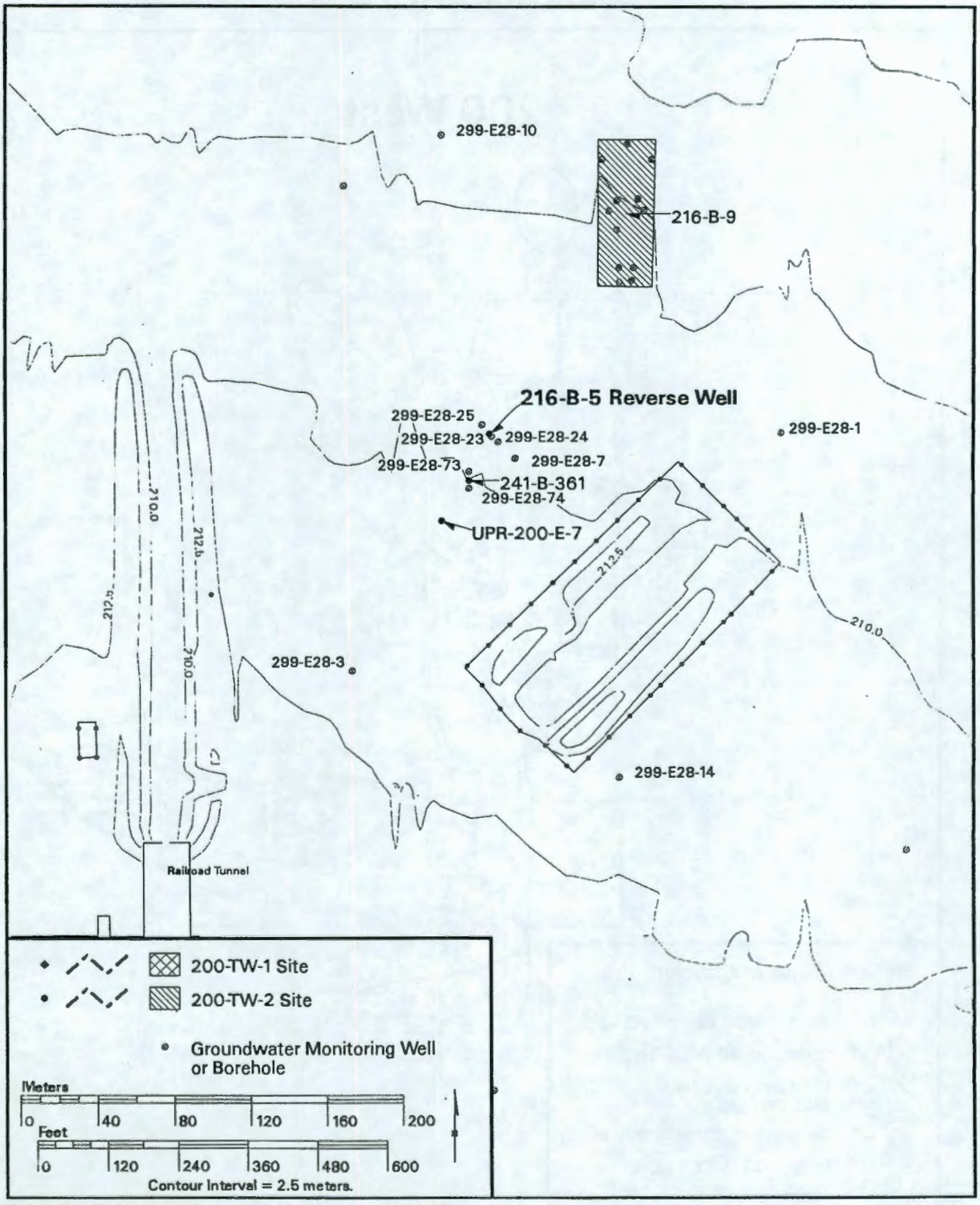
BHI:maa 1/12/00 /home/maaye/amls/rads2west.aml Database: 29-JUN-2000

Figure 3-6. Major Radiological Groundwater Plumes in the Vicinity of the 200 West Area (Modified from PNNL 2000).



BHI:maa 1/12/00 /home/maaye/amls/rads2west.aml Database: 29-JUN-2000

Figure 3-7. 216-B-5 Reverse Well Borehole Location Map.



BHI:maa 01/6/00 /home/maaye/amls/ws430.aml Database: 10-JAN-2000

Figure 3-8. Beta-Gamma Concentrations at the 216-B-5 Reverse Well (Smith 1980).

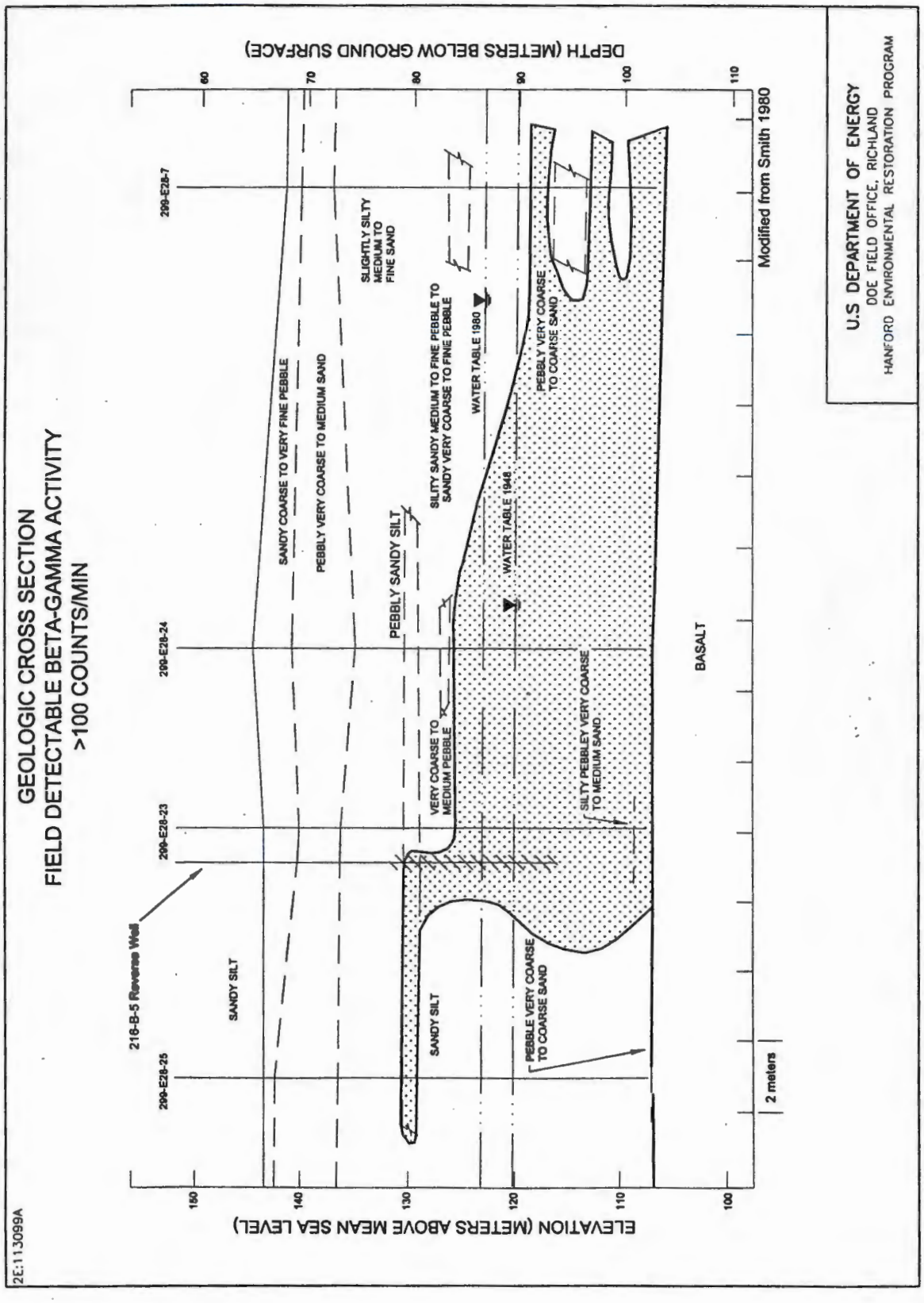


Figure 3-9. Cesium-137 Concentrations at the 216-B-5 Reverse Well (Smith 1980).

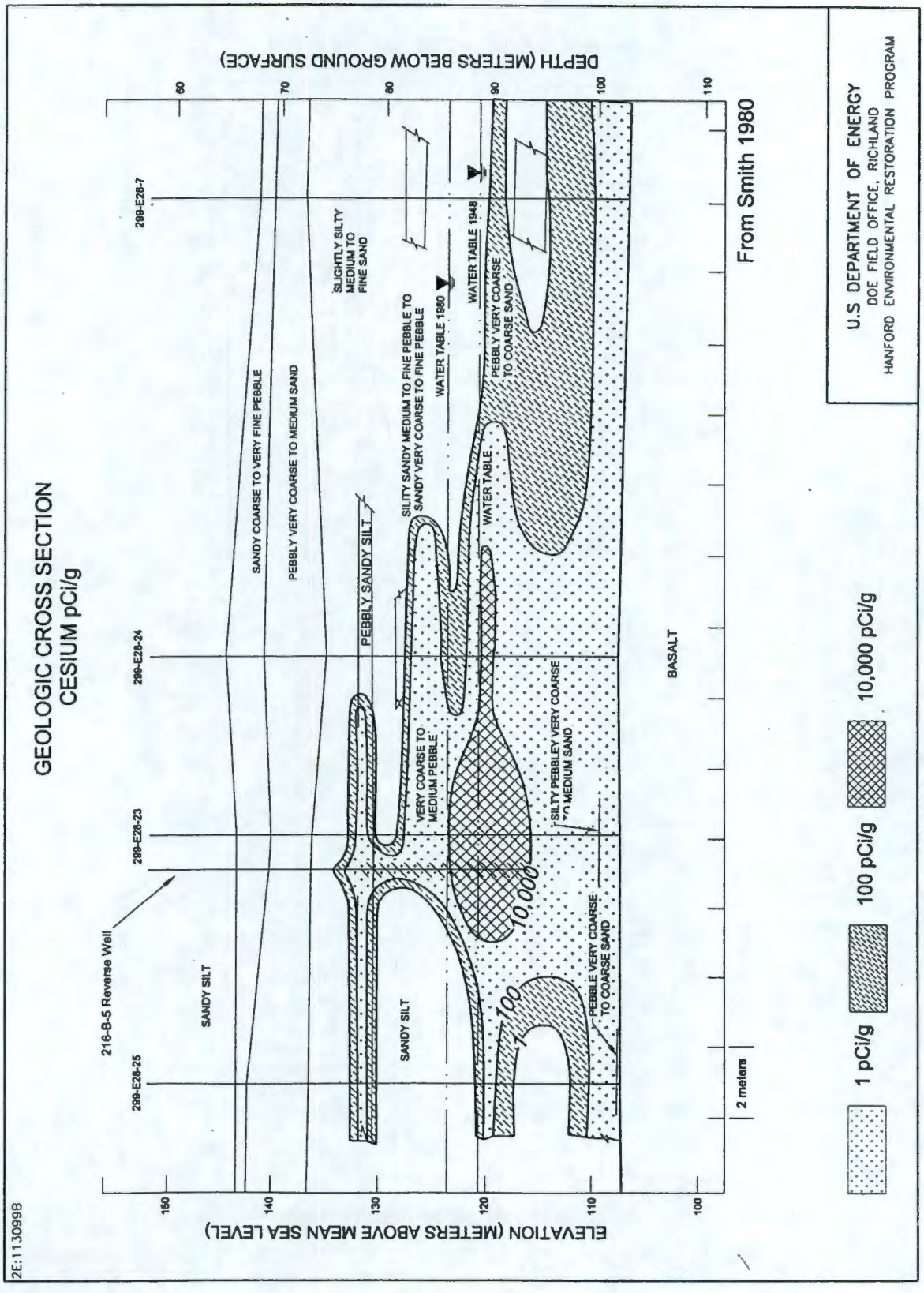


Figure 3-10. Plutonium-239/240 Concentrations at the 216-B-5 Reverse Well (Smith 1980).

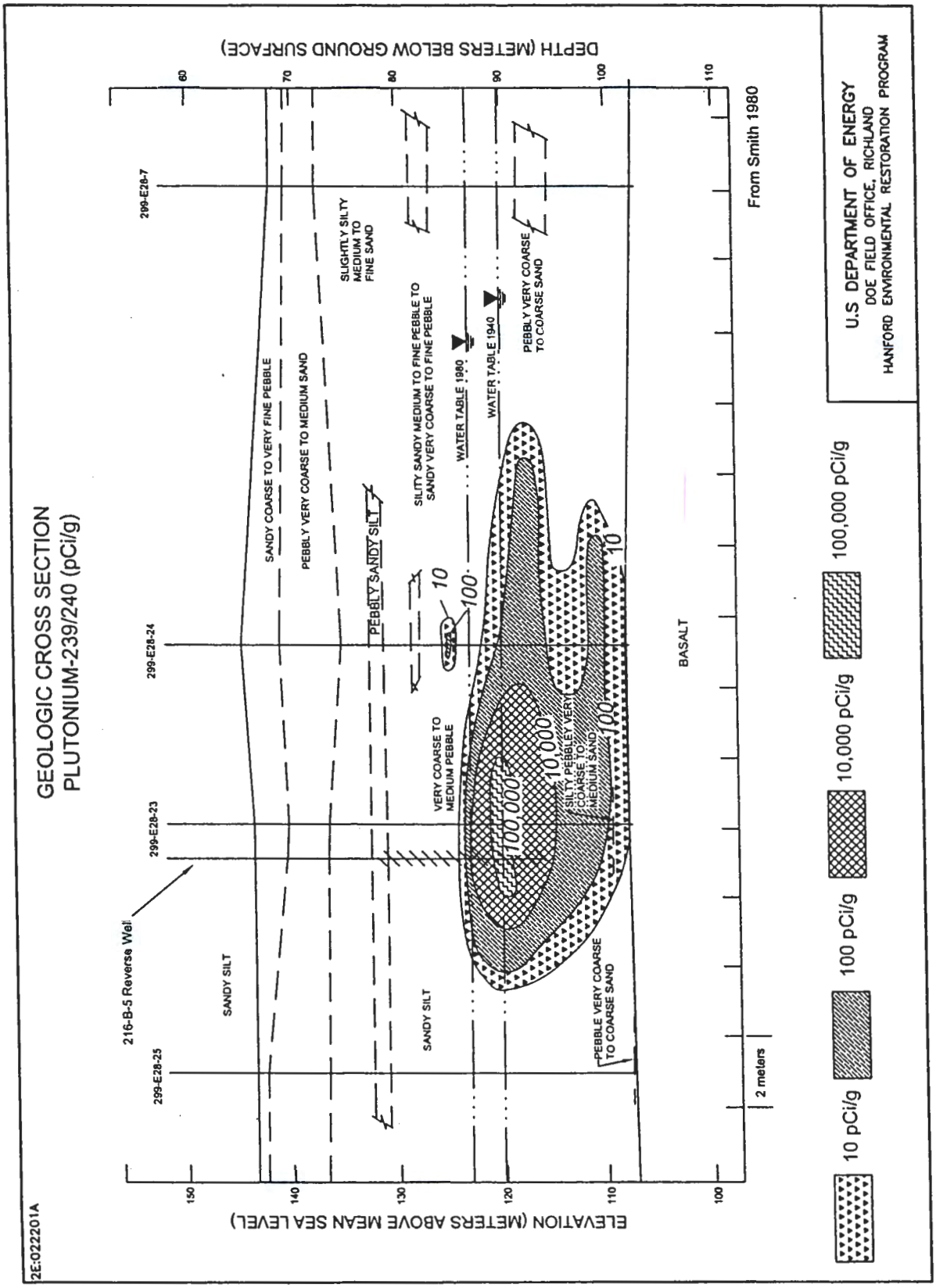


Figure 3-11. Strontium-90 Concentrations at the 216-B-5 Reverse Well (Smith 1980).

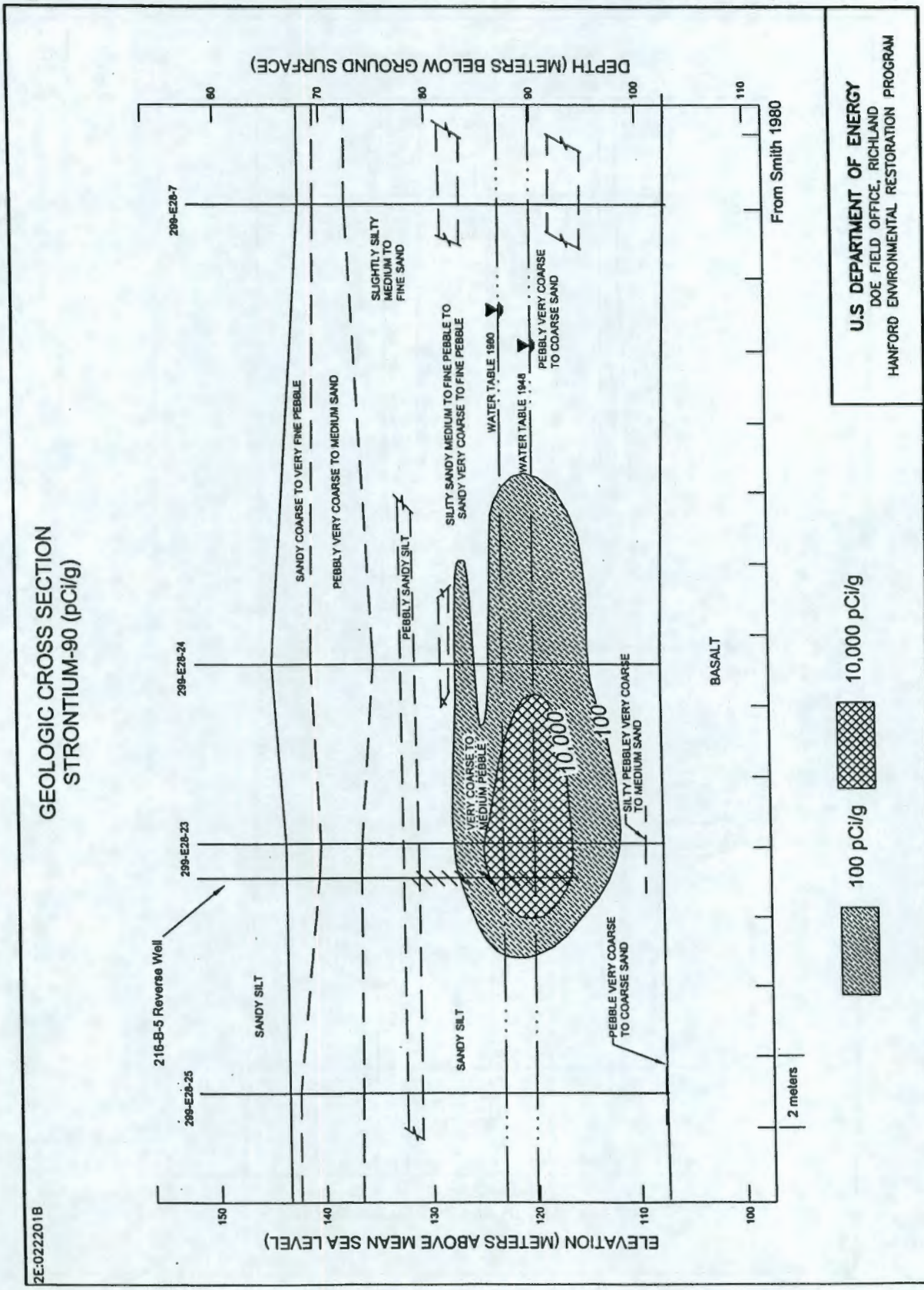
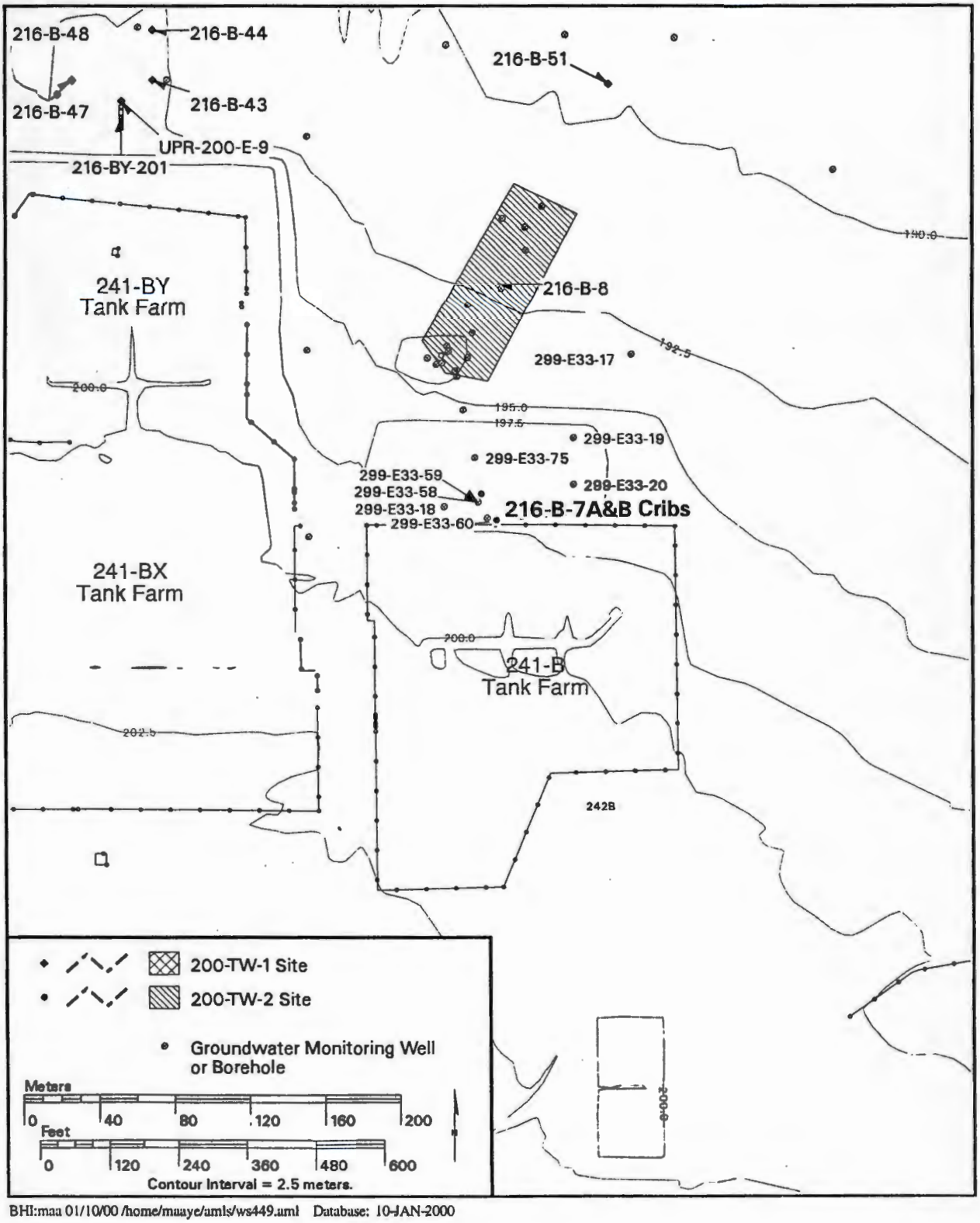
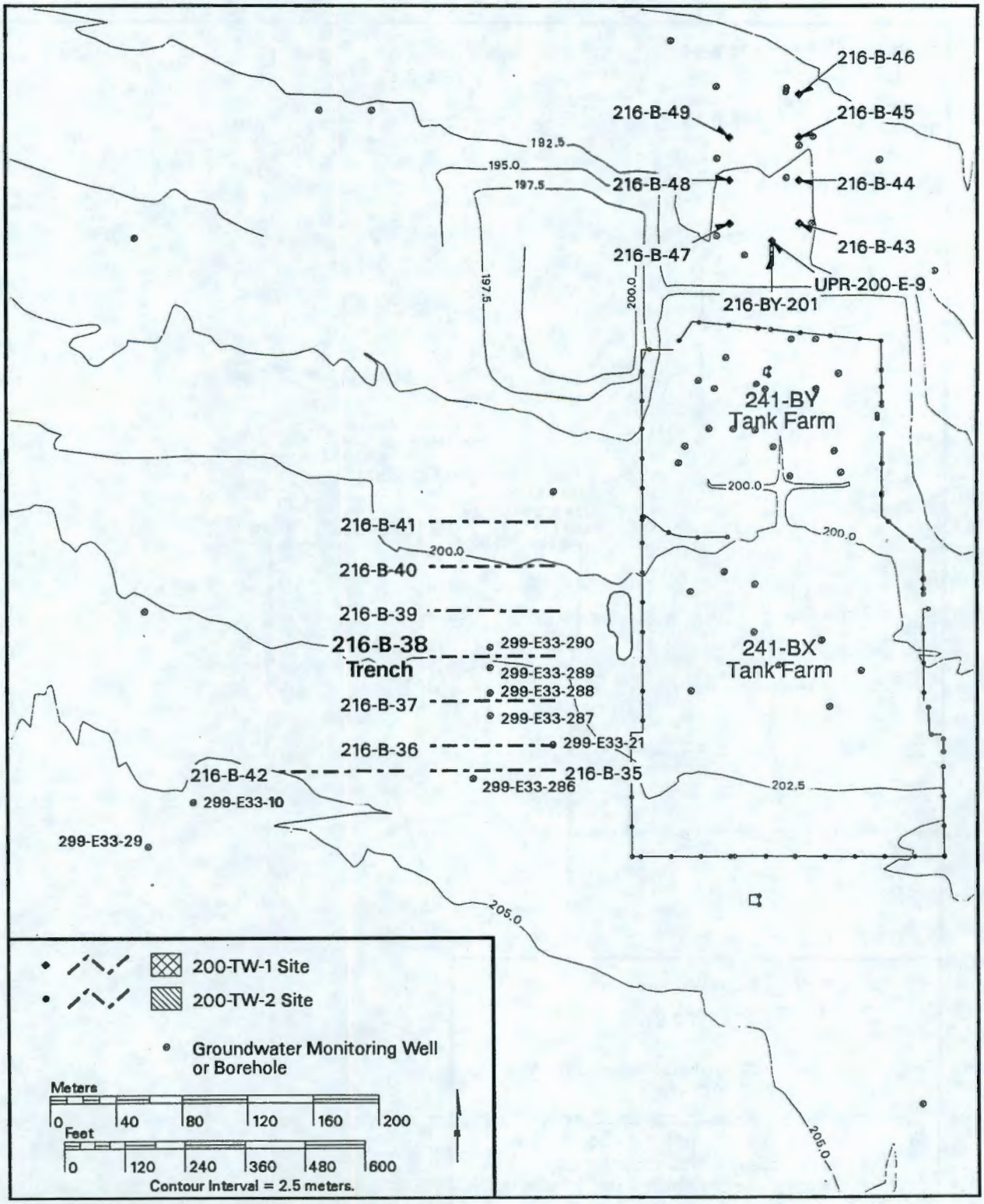


Figure 3-12. 216-B-7A&B Cribs Borehole Location Map.



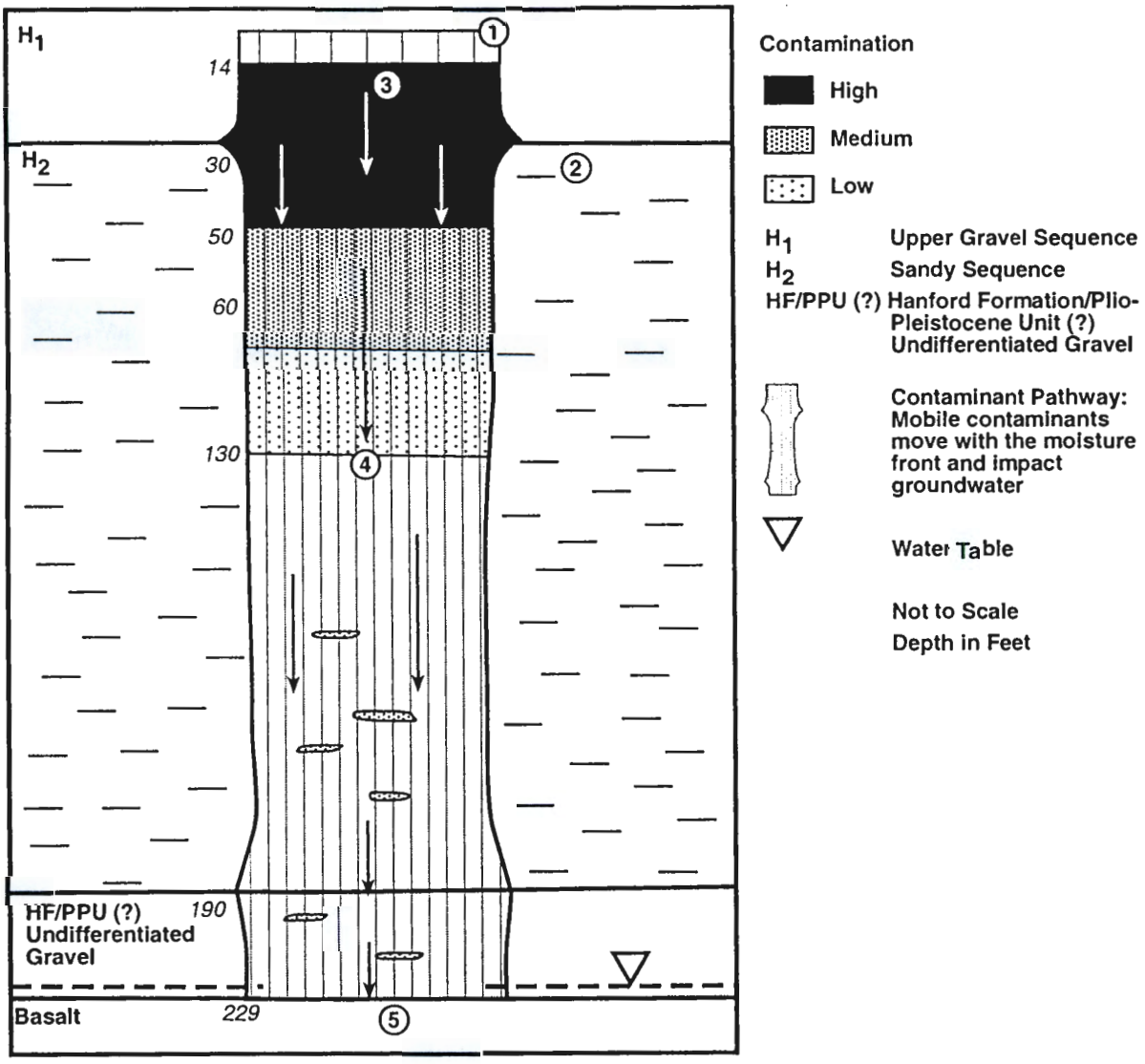
BHI:maa 01/10/00 /home/maaye/amls/ws449.aml Database: 10-JAN-2000

Figure 3-13. 216-B-38 Trench Borehole Location Map.



BHI:maa 01/05/00 /home/maaye/amls/ws414.aml Database: 10-JAN-2000

Figure 3-14. 216-B-46 Crib Conceptual Contaminant Distribution Model.



(1) High salt, neutral/basic, low organic liquid waste containing cesium-137, strontium, cobalt-60, radium-226, and other contaminants from the single shell tank system were discharged to the crib in 1955. The crib received a total volume of 6,700,000L (1.8 million gal) of wastewater.

(2) Effluent and contaminants migrated vertically beneath the crib into H_1, H_2, and HF/PPU (?). There is little or no lateral spreading.

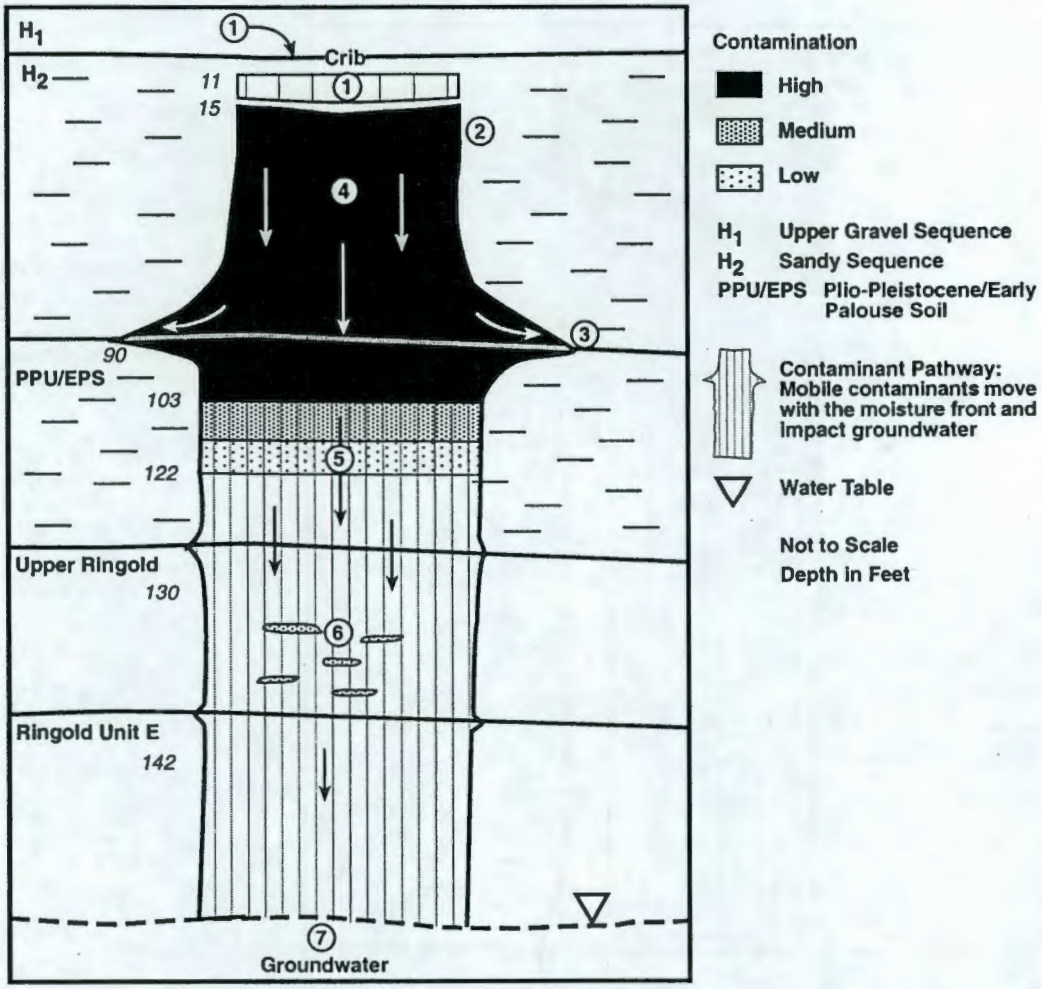
(3) Immobile contaminants, such as cesium-137, sorb near the point of release in high concentration. However, enhanced mobility is indicated at this site because the major zone of contamination is approximately 30 ft. thick. Mobile contaminants such as cobalt-60 migrate with moisture front. Cobalt-60 mobility may be enhanced due to the presence of various ferrocyanide complexants.

(4) Contaminant concentrations generally decreases with depth.

(5) Wastewater and mobile contaminants impact groundwater.

E0004013.5

Figure 3-15. 216-T-26 Crib Conceptual Contaminant Distribution Model.



① High salt, neutral/basic, low organic radioactive liquid waste containing cesium-137, cobalt-60, plutonium-239/240, strontium-90 and other contaminants from the single shell tank system were discharged to the crib between 1955 and 1956. The crib received a total volume of 12,000,000L (3.2 million gal) of wastewater.

② Wastewater moved vertically down beneath the crib into H_2. There is little or no lateral spreading. However, the lack of spreading is not supported by borehole data.

③ Effluent and contaminants intersect the PPU/EPS approximately 90 ft. bgs. Lateral spreading of wastewater and contaminants may occur associated with this unit. If spreading occurs it is to the south based on the topography of the PPU/EPS.

④ Immobile contaminants, such as cesium-137, sorb to the crib and are distributed near the point of release in high concentrations. However, enhanced mobility is indicated at this site as the highly contaminated zone of cesium-137 is 78 ft. thick. Mobile contaminants such as cobalt-60 migrate with the moisture front. Cobalt-60 mobility may be enhanced due to the presence of ferrocyanide complexants.

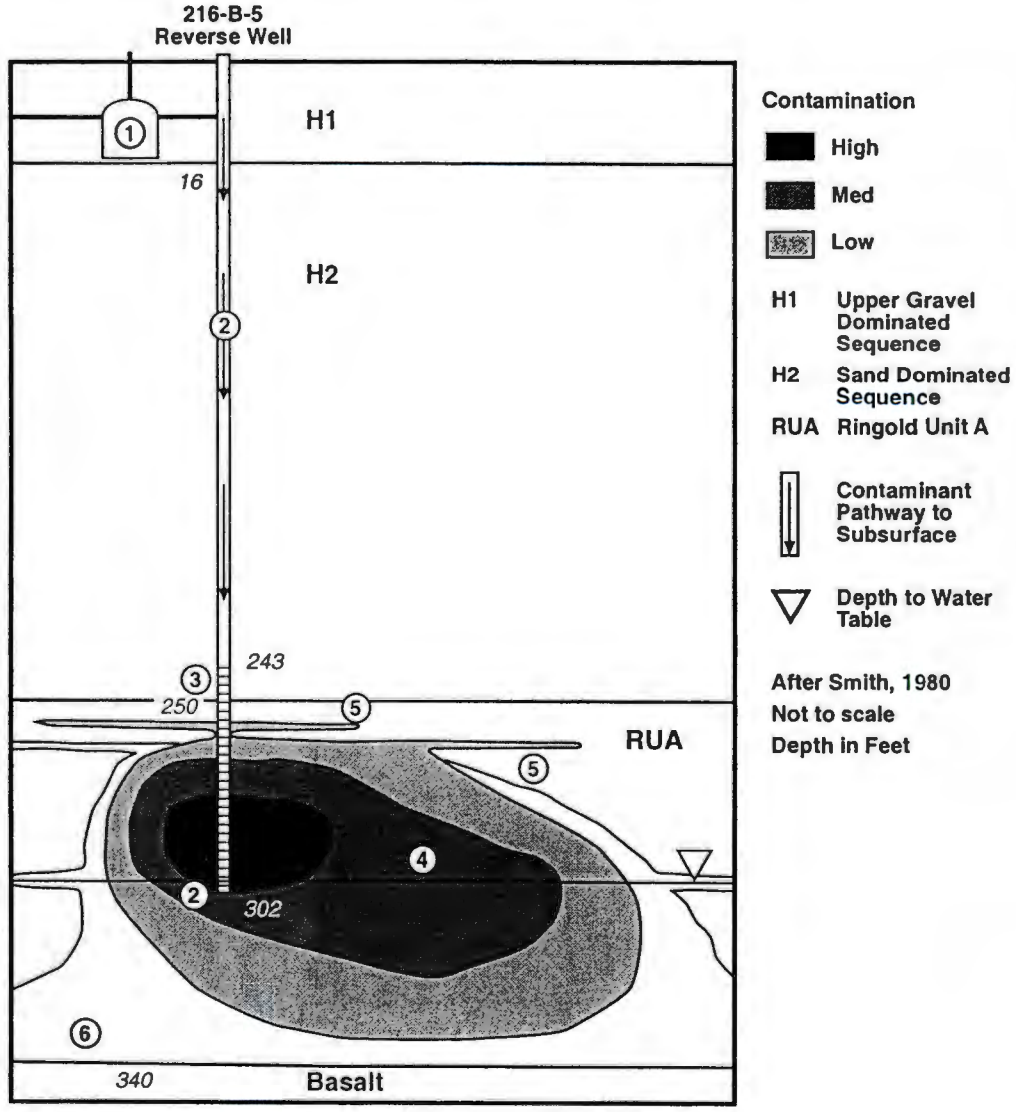
⑤ The activity of cesium-137 decreases with depth; it is not detected greater than 122 ft. bgs.

⑥ Antimony-125 and cobalt-60 were detected at low concentrations to a maximum depth of 140 ft.

⑦ Wastewater and mobile contaminants from the crib impact groundwater.

E9912036.3

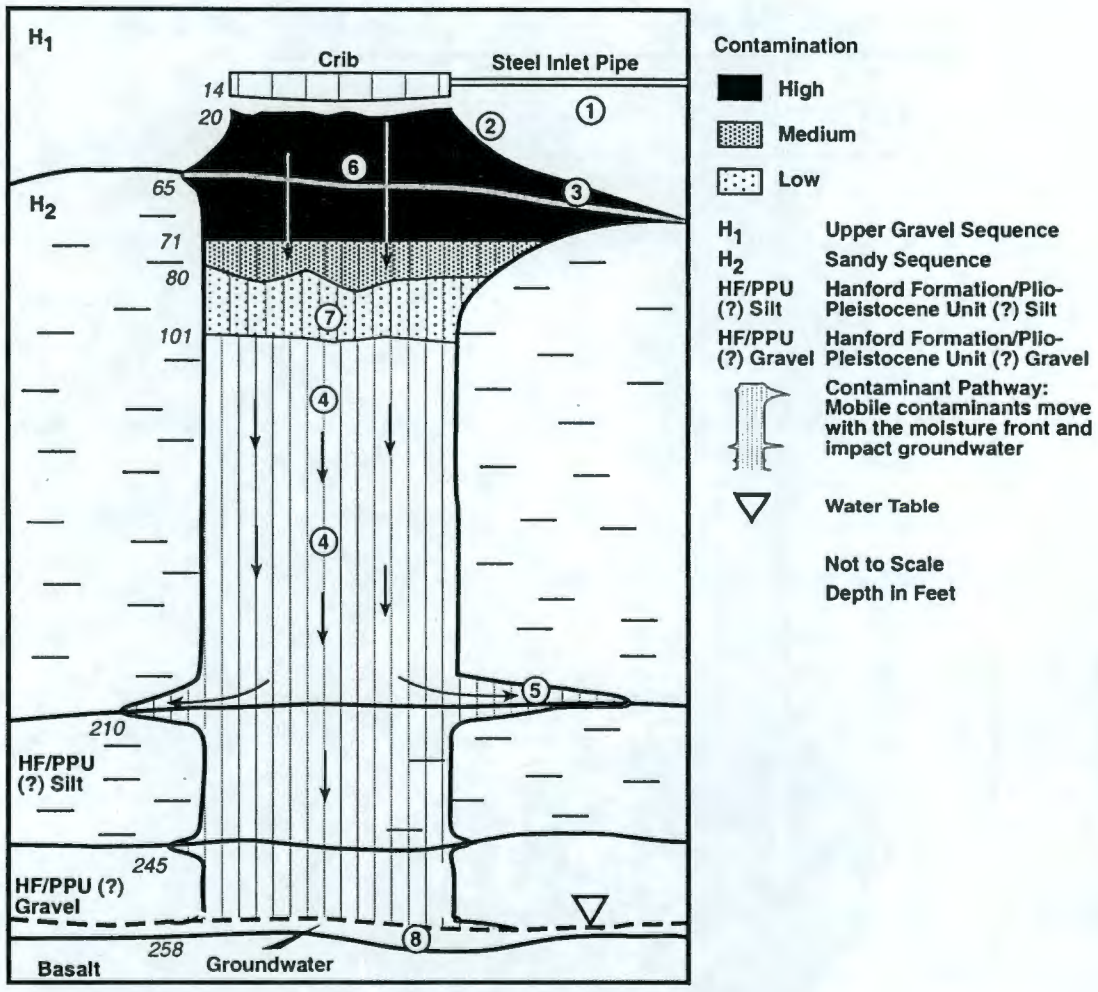
Figure 3-16. 216-B-5 Reverse Well Conceptual Contaminant Distribution Model.



1. High salt, neutral/basic/low organic liquid waste with high quantities of plutonium 239/240. Cesium-137, and strontium-90 were discharged to the 216-B-361 settling tank. Contaminants precipitated/settled out in the tank.
2. Wastewater overflowed from the 216-B-361 settling tank and into the 216-B-5 reverse well through a 5 cm (2-inch) diameter stainless steel inlet pipe about 3.6 m (12 ft) bgs. The reverse well received approximately 30,600,000 L (8.1 million gal) of liquid waste. In addition, studies indicate that the well receive 4.3 kg of Pu.
3. Waste was released to the vadose zone and the water table through a perforated section of the reverse well extending 74 m - 92 m (242 ft - 302 ft) bgs. When the well was actively receiving waste, it penetrated 3 m (10 ft) into the aquifer.
4. Contaminant detected in the subsurface include: cesium-137, strontium-90, plutonium-239/240, and americium-241. The highest activities were detected near the well perforations. Activities generally decrease away from the well.
5. Cesium-137 preferentially sorbs into silt lenses intersected by perforated casing.
6. Plutonium-239/240 may occur in phosphate based mineral phase.
7. The vadose zone and groundwater has been impacted by operation of the 216-B-5 reverse well.

E9912004.1

Figure 3-17. 216-B-7A&B Cribs Conceptual Contaminant Distribution Model.



(1) High salt, neutral/basic, low organic radioactive liquid waste containing Cs-137, plutonium, uranium, strontium-90 and other contaminants from the single shell tank farm system were discharged to the crib between 1946-1967. The cribs received a total volume of 43,600,000L (11,500,00 0 gal.) of wastewater.

(2) The wetting front and contaminants move vertically beneath the cribs into H_1. There is little or no lateral spreading.

(3) Effluent and contaminants migrate laterally on top of H_2 which slopes to the northeast. Lateral spreading may extend at least 80 ft from the crib.

(4) Contaminant flow and transport is mainly vertical beneath the crib in the lower half of H_2 and HF/PPU (?) Gravel.

(5) Significant spreading of the wetting front may occur on top of the HF/PPU (?) Silt.

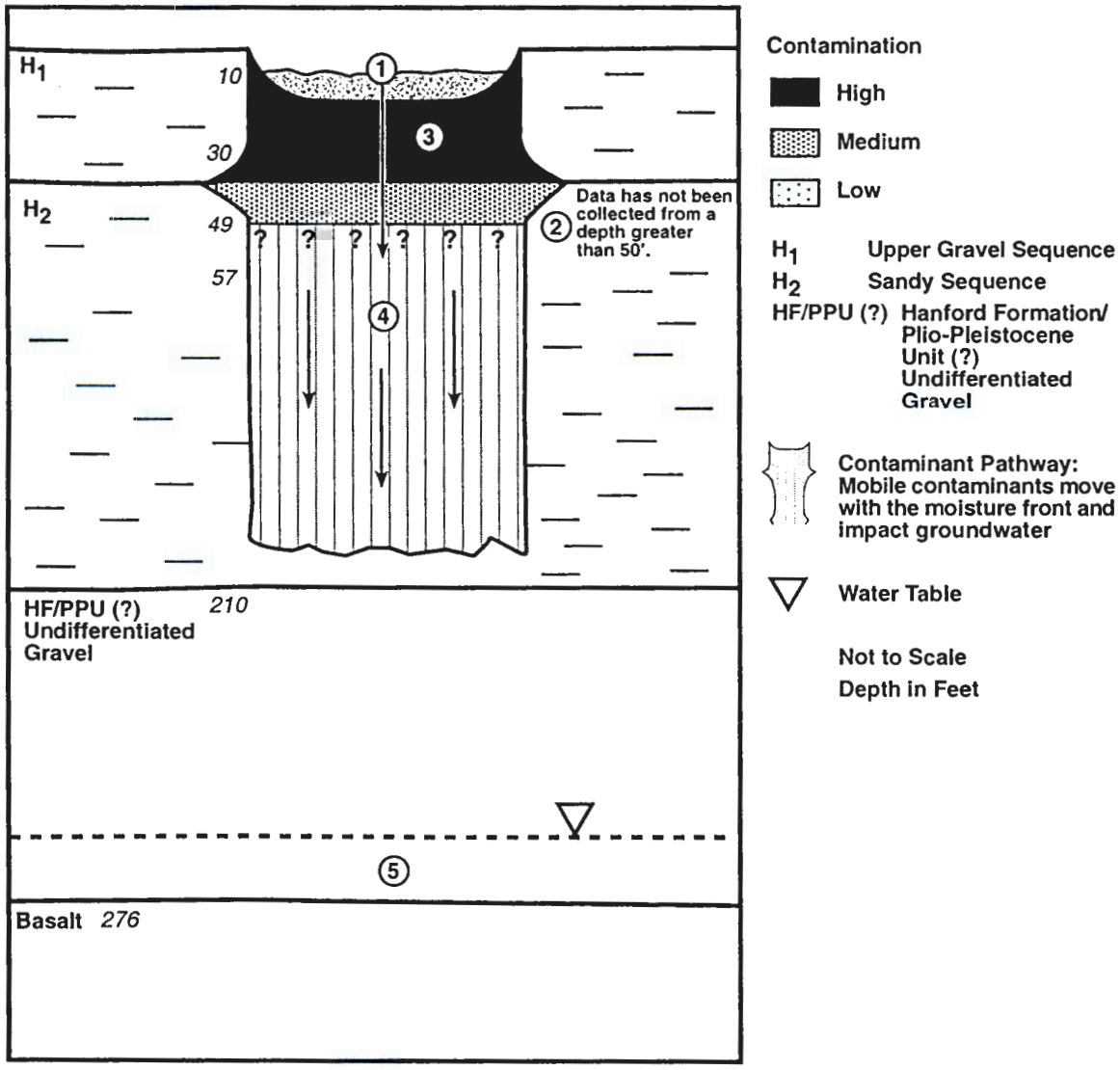
(6) Immobile contaminants, such as cesium-137, sorb to the crib structure and are distributed near the point of release in high concentrations. However, enhanced mobility is indicated at this site as the highly contaminated zone of Cs-137 is approximately 50' thick. Mobile contaminants such as nitrate move with the moisture front.

(7) The activity of cesium-137 decreases with depth. Contamination has not been detected greater than 101 ft. bgs in the vadose zone.

(8) Wastewater and mobile contaminants from the crib impact groundwater.

E0004013.3

Figure 3-18. 216-B-38 Trench Conceptual Contaminant Distribution Model.



(1) High salt, neutral, low organic radioactive waste containing cesium-137, plutonium-239/240, uranium, strontium-90 and other contaminants from the single shell tank farm system were discharged to the trench in 1954. The trench received a total volume of 1,430,000L (380,000 gal.) of wastewater.

(2) Effluent and contaminants were discharged into H_1. The wetting front and contaminants moved vertically down beneath the trench. There is little or no lateral spreading.

(3) Immobile contaminants, such as cesium-137, sorb to the bottom of the trench. The zone of greatest contamination is from the bottom of the trench to about 30 ft. bgs. Contaminant concentrations generally decreases with depth.

(4) The wetting front and mobile contaminants move downward beneath the crib. Data is not available to determine contaminant levels in this zone.

(5) During periods of active discharge, wastewater and mobile contaminants do not impact groundwater. Calculations of soil pore volume in DOE/RL-96-81 suggest that effluent volume does not exceed soil pore volume.

E0004013.1

Figure 3-19. Conceptual Exposure Model for the 200-TW-1 and 200-TW-2 Operable Units.

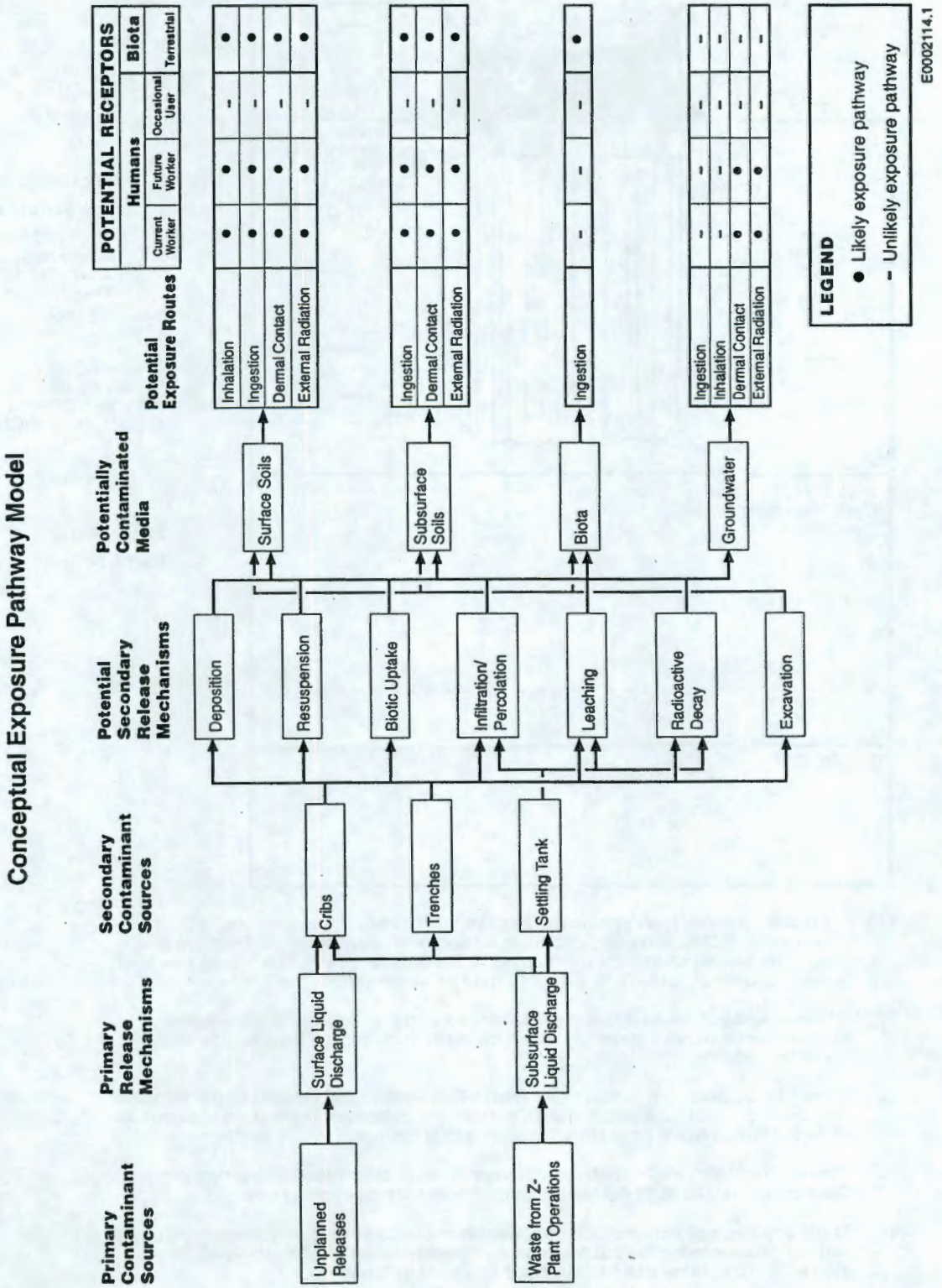


Table 3-1. 200-TW-1 Operable Unit – Estimated Contaminant Inventory. (2 Pages)

Site	Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	CCl_4 (kg)	Ferro-cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)	Effluent Volume (m^3)	Pore Volume (m^3)	Effluent Volume/Pore Volume
200-TW-1 Scavenged Waste Group Operable Unit															
Sites That Received Scavenging Test Effluent															
216-T-18	2.68E+01	1.80E+03	--	2.42E+01	2.80E+00	--	--	--	80000	--	--	--	1000	699	1.430615165
Sites That Received Scavenged TBP Waste Stream															
216-B-14	2.20E+02	2.50E+01	--	1.14E+02	1.72E+02	--	5000	--	1500000	--	--	--	8710	17670	0.492925863
216-B-15	1.00E+02	5.00E+00	--	9.24E+01	8.73E+01	--	3300	--	900000	--	--	--	6320	17670	0.357668364
216-B-16	3.20E+02	1.00E+01	--	2.96E+02	3.02E+02	--	3000	--	1100000	--	--	--	5600	17670	0.316921336
216-B-17	3.50E+02	1.00E+01	--	1.00E+02	6.89E+01	--	1800	--	1100000	--	--	--	3410	17670	0.192982456
216-B-18	2.40E+02	1.00E+01	--	1.14E+02	8.18E+01	--	5000	--	1000000	--	--	--	8520	17670	0.482173175
216-B-19	1.80E+02	1.00E+01	--	1.26E+02	8.83E+01	--	3400	--	1500000	--	--	--	6400	17670	0.362195812
216-B-20	3.50E+02	1.30E+00	--	6.84E+02	3.40E+02	--	2500	--	1100000	--	--	--	4680	13670	0.342355523
216-B-21	6.80E+02	1.03E+01	--	1.69E+02	3.18E+02	--	--	--	--	--	--	--	4670	13950	0.334767025
216-B-22	4.20E+02	2.60E+00	--	2.05E+01	1.76E+02	--	2500	--	900000	--	--	--	4740	13800	0.343478261
216-B-23	1.60E+02	1.80E+00	--	5.09E+01	6.25E+01	--	2400	--	1000000	--	--	--	4520	13390	0.337565347
216-B-24	2.50E+02	7.70E+01	--	5.86E+01	7.80E+01	--	2500	--	600000	--	--	--	4700	13670	0.343818581
216-B-25	1.50E+02	2.00E+00	--	2.55E+01	8.83E+01	--	2000	--	500000	--	--	--	3760	13260	0.283559578
216-B-26	5.90E+02	2.50E+00	--	4.38E+02	4.75E+02	--	3100	--	800000	--	--	--	5880	13390	0.439133682
216-B-27	3.40E+02	7.00E+01	--	1.58E+01	2.63E+02	--	2300	--	600000	--	--	--	4420	13390	0.330097087
216-B-28	3.00E+02	5.60E+00	--	1.07E+01	4.95E+01	--	2700	--	1000000	--	--	--	5050	13530	0.373244642
216-B-29	3.40E+02	1.10E+00	--	2.74E+01	8.48E+01	--	2600	--	700000	--	--	--	4840	13530	0.357723577
216-B-30	8.80E+01	2.10E+00	--	1.57E+03	2.65E+02	--	2500	--	1100000	--	--	--	4780	13530	0.353288987
216-B-31	1.20E+02	--	--	--	--	--	2500	--	1100000	--	--	--	4740	13530	0.350332594
216-B-32	1.10E+01	2.60E+00	--	5.86E+01	1.13E+02	--	2500	--	1000000	--	--	--	4770	13530	0.352549889
216-B-33	2.00E+01	1.18E+01	--	1.27E+02	1.81E+01	--	2500	--	1700000	--	--	--	4740	13530	0.350332594
216-B-34	8.50E+01	5.70E+00	--	7.91E+00	1.81E+01	--	2600	--	1900000	--	--	--	4870	13530	0.359940872
216-B-42	6.80E+02	1.00E+01	--	4.27E+01	4.63E+02	--	800	--	210000	--	--	--	1500	5265	0.284900285
216-B-43	1.40E+01	5.00E-01	--	1.30E+02	5.74E+02	--	1100	--	400000	--	--	--	2120	10200	0.207843137
216-B-44	5.30E+00	1.50E+01	--	3.09E+02	1.20E+03	--	3000	--	800000	--	--	--	5600	9885	0.566514922
216-B-45	6.80E+00	1.00E+01	--	6.66E+02	1.18E+03	--	2600	--	90000	--	--	--	4920	9885	0.497723824
216-B-46	**1.90E+02**	**2.00E+01**	**--**	**8.89E+01**	**6.31E+02**	**--**	**4000**	**--**	**1200000**	**--**	**--**	**--**	**6700**	**9730**	**0.688591984**
216-B-47	6.80E+00	5.00E+00	--	6.66E+01	2.61E+02	--	2000	--	700000	--	--	--	3710	10355	0.358281024

Table 3-1. 200-TW-1 Operable Unit – Estimated Contaminant Inventory. (2 Pages)

Site	Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	CCl_4 (kg)	Ferro-cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)	Effluent Volume (m^3)	Pore Volume (m^3)	Effluent Volume/Pore Volume
216-B-48	2.30E+00	5.00E+00	--	2.00E+02	5.47E+02	--	2200	--	1000000	--	--	--	4090	10042	**0.407289385**
216-B-49	3.20E+02	1.50E+01	--	1.82E+02	1.14E+03	--	4000	--	1500000	--	--	--	6700	9885	**0.677794638**
216-B-51	--	--	--	--	--	--	--	--	190	--	--	--	1	135	**0.007407407**
216-T-26	**1.50E+02**	**5.90E+01**	**--**	**7.56E+01**	**2.82E+02**	**--**	**6000**	**--**	**1000000**	**--**	**--**	**--**	**12000**	**680**	**17.64705882**
200-E-14	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sites That Received In Tank or In Tank Farm Scavenged Waste Stream															
216-B-17	3.50E+02	1.00E+01	--	1.00E+02	6.89E+01	--	1800	--	1100000	--	--	--	3410	17670	**0.192982456**
216-B-19	1.80E+02	1.00E+01	--	1.26E+02	8.83E+01	--	3400	--	1500000	--	--	--	6400	17670	**0.362195812**
216-B-20	3.50E+02	1.30E+00	--	6.84E+02	3.40E+02	--	2500	--	1100000	--	--	--	4680	13670	**0.342355523**
216-B-21	6.80E+02	1.03E+01	--	1.69E+02	3.18E+02	--	--	--	--	--	--	--	4670	13950	**0.334767025**
216-B-22	4.20E+02	2.60E+00	--	2.05E+01	1.76E+02	--	2500	--	900000	--	--	--	4740	13800	**0.343478261**
216-B-23	1.60E+02	1.80E+00	--	5.09E+01	6.25E+01	--	2400	--	1000000	--	--	--	4520	13390	**0.337565347**
216-B-28	3.00E+02	5.60E+00	--	1.07E+01	4.95E+01	--	2700	--	1000000	--	--	--	5050	13530	**0.373244642**
216-B-30	8.80E+01	2.10E+00	--	1.57E+03	2.65E+02	--	2500	--	1100000	--	--	--	4780	13530	**0.353288987**
216-B-31	1.20E+02	--	--	--	--	--	2500	--	1100000	--	--	--	4740	13530	**0.350332594**
216-B-32	1.10E+01	2.60E+00	--	5.86E+01	1.13E+02	--	2500	--	1000000	--	--	--	4770	13530	**0.352549889**
216-B-33	2.00E+01	1.18E+01	--	1.27E+02	1.81E+01	--	2500	--	1700000	--	--	--	4740	13530	**0.350332594**
216-B-34	8.50E+01	5.70E+00	--	7.91E+00	1.81E+01	--	2600	--	1900000	--	--	--	4870	13530	**0.359940872**
216-B-52	3.00E+01	1.90E+01	--	1.60E+02	4.92E+00	--	5000	--	2100000	--	--	--	8530	15710	**0.542966264**
216-BY-201	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

NOTES: All inventories taken from Table 2-2 or Table 2-3 of the 200 Area Source Aggregate Area Management Study Reports (e.g., DOE-RL 1992, 1993a, 1993b, 1993d). All radionuclide inventories decayed through 1989 unless otherwise noted in the AAMSR. Bold indicates site was selected as a representative site in the Implementation Plan (DOE-RL 1999) and the Waste Site Grouping Report (DOE-RL 1997).
-- = data not available.

Table 3-2. 200-TW-2 Operable Unit – Estimated Contaminant Inventory.

Site	Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	CCl_4 (kg)	Ferro-cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)	Effluent Volume (m^3)	Pore Volume (m^3)	Effluent Volume/Pore Volume
200-TW-2 Tank Waste Group Operable Unit															
Sites That Received 2nd Cycle, Cell 5-6 Drainage, and Lanthanum-Fluoride Waste Streams															
216-B-5	--	**4.27E+03**	--	**2.92E+01**	**2.55E+01**	--	--	--	400000	--	--	--	30600	--	--
216-B-7A&B	**1.80E+02**	**4.30E+03**	--	**4.32E+01**	**2.20E+03**	--	--	--	1800000	--	--	--	43600	558	78.13620072
216-B-8	4.50E+01	3.00E+01	--	1.98E+01	5.58E+00	--	--	--	1400000	--	--	--	27200	52730	0.515835388
216-B-9	4.50E+01	1.74E+02	--	3.92E+00	5.52E+00	--	--	--	1000	--	--	--	36000	25990	1.385148134
216-T-3	--	3.35E+03	--	2.13E+01	1.86E+01	--	--	--	290000	--	--	--	11300	--	--
216-T-5	5.94E+00	1.80E+02	--	3.11E+01	4.20E-01	--	--	--	140000	--	--	--	2600	953	2.728226653
216-T-6	2.26E+01	3.90E+02	--	1.10E+02	1.24E+02	--	--	--	180000	--	--	--	45000	1305	34.48275862
216-T-7	8.92E+00	1.30E+02	--	2.12E+01	2.40E+01	--	--	--	2300000	--	--	--	110000	8906	12.35122389
216-T-32	2.38E+01	3.20E+03	--	9.71E+00	1.09E+01	--	--	--	1200000	--	--	--	29000	2644	10.96822995
241-B-361	1.10E+00	--	--	--	--	--	--	--	--	--	--	--	--	--	--
241-T-361	--	2.00E+03	--	--	--	--	--	--	--	--	--	--	--	--	--
Sites That Received Dissolved Cladding and 1st Cycle Waste Streams															
216-B-35	1.70E+01	1.20E+00	--	1.85E+02	9.64E+01	--	--	--	90000	--	--	--	1060	5190	0.204238921
216-B-36	1.60E+01	8.00E-01	--	3.36E+02	1.99E+02	--	--	--	160000	--	--	--	1940	5190	0.373795761
216-B-37	3.60E+00	2.00E+00	--	1.35E+03	6.56E+00	--	--	--	1700000	--	--	--	4320	5130	0.842105263
216-B-38	**4.20E+01**	**1.20E+00**	--	**2.21E+02**	**7.59E+02**	--	--	--	**120000**	--	--	--	**1430**	**5055**	0.282888229
216-B-39	5.80E+00	1.51E+00	--	1.92E+02	9.27E+00	--	--	--	120000	--	--	--	1540	5055	0.304648863
216-B-40	3.50E+01	1.00E+00	--	1.53E+02	1.15E+02	--	--	--	130000	--	--	--	1640	4920	0.333333333
216-B-41	7.50E+00	3.00E-01	--	3.86E+02	1.93E+01	--	--	--	120000	--	--	--	1440	4920	0.292682927
216-T-14	3.03E+01	8.80E-01	--	2.04E+02	2.46E+00	--	--	--	80000	--	--	--	1000	4943	0.202306292
216-T-15	2.71E+01	9.40E-01	--	4.50E+02	8.62E+00	--	--	--	80000	--	--	--	1000	4943	0.202306292
216-T-16	2.20E+01	6.50E-01	--	2.27E+02	3.28E+00	--	--	--	80000	--	--	--	1000	4943	0.202306292
216-T-17	2.02E+01	5.30E-01	--	1.62E+02	1.23E+00	--	--	--	60000	--	--	--	1000	4943	0.202306292
216-T-21	8.90E-01	1.00E+00	--	1.74E+02	3.28E+00	--	--	--	40000	--	--	--	460	3730	0.123324397
216-T-22	2.08E+00	2.00E+00	--	8.03E+02	2.09E+01	--	--	--	120000	--	--	--	1530	3730	0.410187668
216-T-23	8.90E-01	1.00E+00	--	5.77E+02	1.68E+01	--	--	--	120000	--	--	--	1480	3730	0.396782842
216-T-24	8.92E+00	2.00E+00	--	6.17E+02	1.64E+01	--	--	--	120000	--	--	--	1530	3730	0.410187668
216-T-25	8.92E+00	1.00E+00	--	3.86E+03	1.64E+00	--	--	--	1200000	--	--	--	3000	2797	1.072577762
216-T-30	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
UPR-200-E-7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

NOTES: All inventories taken from Table 2-2 or Table 2-3 of the 200 Area Source Aggregate Area Management Study Reports (e.g., DOE-RL 1992, 1993a, 1993b, 1993d). All radionuclide inventories decayed through 1989 unless otherwise noted in the AAMSR. Bold indicates site was selected as a representative site in the Implementation Plan (DOE-RL 1999) and the Waste Site Grouping Report (DOE-RL 1997).
-- = data not available.

Table 3-3. 1998 Soil and Vegetation Data (in pCi/g)[a] (2 Pages).

Isotope	Vicinity of T, TX, and TY Tank Farms					Near 216-B-46 Crib	Near 216-B-7A&B Cribs	Vicinity of 241-B Tank Farm
	Soil (D012)	Soil (D014)	Soil (D016)	Soil (D018)	Soil (D036)	Soil (D054)	Soil (D056)	Soil (D058)
Co-60	3.4E-03	3.2E-03	2.2E-03	2.1E-04	-2.0E-03	4.2E-03	3.2E-03	4.3E-03
Zn-65	-6.3E-03	-7.2E-03	-3.7E-03	-1.3E-02	-1.2E-02	-8.0E-03	-1.4E-03	-1.1E-02
Sr-90	2.3E-03	2.5E-01	-8.1E-04	6.6E-01	-5.6E-02	-5.1E-02	4.2E-02	7.6E-01
Ru-103	-2.8E-03	3.9E-04	-1.8E-03	3.5E-04	-7.1E-04	-6.4E-03	-7.7E-04	-1.3E-02
Ru-106	-4.4E-03	-3.0E-02	-4.1E-02	5.1E-03	1.1E-03	-2.9E-04	2.1E-02	-6.3E-02
Sn-113	3.7E-03	-8.8E-03	-9.3E-06	-1.6E-02	6.0E-03	-1.9E-02	-6.3E-03	-1.4E-03
Sb-125	-1.0E-04	-1.0E-02	1.2E-02	-2.9E-02	-1.9E-02	-3.8E-03	2.3E-02	4.0E-03
Cs-134	2.9E-02	2.4E-02	2.7E-02	2.6E-02	2.6E-02	3.4E-02	2.9E-02	3.6E-02
Cs-137	1.2E+00	3.4E+00	1.3E+00	3.8E+00	2.8E-01	7.5E-01	1.9E+00	3.3E+00
Ce-144	1.1E-03	-1.6E-02	-2.6E-02	-3.9E-02	-6.2E-02	-1.8E-02	6.7E-02	-5.2E-02
Eu-152	-3.3E-02	-9.3E-03	1.9E-03	2.0E-02	-1.7E-02	-7.2E-03	8.6E-03	-2.5E-02
Eu-154	-1.3E-02	-7.5E-03	5.4E-04	-2.6E-03	-4.9E-03	-1.2E-02	-8.7E-03	-1.2E-02
Eu-155	1.7E-02	5.4E-02	1.5E-02	2.6E-02	3.7E-02	9.7E-02	1.5E-02	3.3E-02
U-234	1.9E-01	2.1E-01	2.2E-01	2.1E-01	1.7E-01	1.8E-01	1.8E-01	1.7E-01
U-235	1.0E-02	1.4E-02	1.6E-02	2.2E-02	1.7E-02	2.2E-02	1.7E-02	2.2E-02
U-238	2.0E-01	2.4E-01	2.0E-01	2.0E-01	1.7E-01	1.9E-01	1.7E-01	1.7E-01
Pu-238	-2.0E-03	-5.9E-03	2.9E-03	3.4E-03	-4.8E-03	-8.4E-03	2.2E-02	1.0E-02
Pu-239/240	2.2E-02	4.9E-03	1.1E-02	4.0E-02	7.6E-03	7.2E-03	4.4E-03	4.6E-02
Isotope	Vicinity of T, TX, and TY Tank Farms					Near 216-B-46 Crib	Near 216-B-7A&B Cribs	Vicinity of 241-B Tank Farm
	Vegetation (V012)	Vegetation (V014)	Vegetation (V016)	Vegetation (V018)	Vegetation (V036)	Vegetation (V054)	Vegetation (V056)	Vegetation (V058)
Co-60	6.9E-02	NA	-1.4E-03	4.3E-03	2.8E-03	4.8E-03	1.4E-02	5.9E-03
Zn-65	-6.6E-02	NA	3.5E-02	-4.5E-02	9.1E-02	-9.8E-02	-3.5E-02	-2.3E-01
Sr-90	3.9E-02	NA	4.0E-03	6.8E-02	2.5E-02	-5.0E-02	9.0E-02	1.2E+00
Ru-103	1.4E-02	NA	2.3E-02	-2.6E-02	1.8E-02	-6.6E-03	5.9E-03	1.8E-02
Ru-106	-1.2E-01	NA	8.4E-02	3.0E-01	-4.7E-01	-1.9E-01	-1.3E-01	-7.3E-02
Sn-113	-2.3E-02	NA	2.0E-02	4.6E-02	-7.4E-03	-6.1E-03	1.3E-02	-2.6E-02
Sb-125	-4.6E-02	NA	-4.9E-02	2.1E-02	-2.7E-02	5.1E-02	-1.1E-01	2.0E-02
Cs-134	2.8E-02	NA	3.5E-02	-4.1E-02	-4.4E-02	1.9E-02	2.0E-02	2.5E-03

Table 3-3. 1998 Soil and Vegetation Data (in pCi/g)[a] (2 Pages).

	Vicinity of T, TX, and TY Tank Farms					Near 216-B-46 Crib	Near 216-B-7A&B Cribs	Vicinity of 241-B Tank Farm
Isotope	Vegetation (V012)	Vegetation (V014)	Vegetation (V016)	Vegetation (V018)	Vegetation (V036)	Vegetation (V054)	Vegetation (V056)	Vegetation (V058)
Cs-137	2.5E-02	NA	1.1E-02	-2.1E-02	3.4E-02	1.1E-01	3.0E-01	2.1E-01
Ce-144	2.0E-01	NA	1.1E-02	-5.0E-02	1.2E-01	1.3E-03	-2.3E-01	-8.3E-02
Eu-152	-5.0E-03	NA	-4.2E-02	7.1E-02	3.4E-02	1.3E-02	3.3E-02	4.1E-01
Eu-154	2.6E-03	NA	-4.6E-02	-6.4E-02	-1.0E-02	-2.1E-02	-1.3E-01	-2.9E-02
Eu-155	7.7E-02	NA	-4.9E-02	1.8E-01	1.1E-02	-8.2E-02	5.8E-02	-4.3E-02
U-234	1.3E-02	NA	1.2E-02	2.1E-02	1.3E-02	8.4E-03	6.6E-03	8.2E-03
U-235	2.7E-03	NA	4.3E-03	1.2E-02	2.4E-03	2.0E-03	2.9E-03	5.6E-03
U-238	7.9E-03	NA	5.9E-03	1.3E-02	7.3E-03	4.2E-03	6.6E-03	6.1E-03
Pu-238	3.1E-03	NA	-3.2E-02	-3.0E-03	5.0E-04	4.8E-03	7.0E-04	9.0E-03
Pu-239/240	4.4E-04	NA	3.2E-02	7.0E-04	5.2E-04	2.8E-02	3.3E-03	2.0E-03

[a]Data from the *Hanford Site Near-Facility Environmental Monitoring Data Report for Calendar Year 1998* (PNNL 1999b).

Table 3-4. Range of Environmental Sample Results for B Pond, 216-T-14 Ditch, and Control Site.

Contaminant	B Pond Soils	B Pond Vegetation	B Pond Animals	216-T-4 Ditch Soils	216-T-4 Ditch Vegetation	216-T-4 Ditch Animals	Control Site Soils	Control Site Vegetation	Control Site Animals
Cobalt-60	ND	ND	ND	ND – 0.88	ND – 0.3	ND	ND	ND	ND
Strontium-90	0.35 – 0.97	0.064 – 4.1	ND	0.36 – 2.3	0.13 – 4.2	ND – 16	0.059 – 0.099	ND – 0.17	ND
Cesium-137	0.32 – 1.1	ND – 2.6	ND – 0.11	0.72 - 67	0.24 – 8.6	ND – 10	0.082 – 0.095	ND	ND
Total uranium	2.6 – 3.6	ND	ND	ND – 2.9	ND	ND	2.7 – 3.4	ND	ND
Technetium-99	ND	ND	NA	ND	ND	NA	ND	ND	NA
Arsenic	2.9 – 4.1	ND – 3.1	ND	1.1 – 1.7	ND –4.2	ND	0.92 – 1.1	ND	ND
Cadmium	ND	ND – 6.0	ND – 1	ND	ND – 9.9	ND	ND	ND	ND
Chromium	5.7 – 6.6	ND – 8.6	ND – 1	4.7 – 10.3	ND – 21.8	ND	8.4 – 11.5	ND	ND
Cobalt	8.7 – 10.1	ND – 11.1	ND	7.3 – 9.7	ND – 7.8	ND	7.5 – 8.5	ND	ND
Copper	8.2 – 9.7	8.0 – 25.2	ND	8 – 24.4	5.4 – 279	ND	8.6 – 9	ND – 3.7	ND
Lead	5.0 – 6.4	ND – 14.0	ND – 1.3	3.8 – 8.8	ND – 50.5	ND – 0.13	3.6 – 3.7	ND	ND – 0.15
Mercury	ND	ND – 0.22	ND – 0.6	ND – 0.59	ND – 3.0	ND	ND	ND	ND
Nickel	5.0 – 6.0	ND – 8.4	ND	6.4 – 8.1	ND	ND	9.9 – 11.5	ND	ND
Selenium	ND	ND	ND – 0.49	ND	ND	0.18 – 0.29	ND	ND	0.16 – 0.29
Silver	ND	ND	ND	ND – 1.7	ND	ND	ND	ND	ND
Zinc	33.3 – 46.1	30.5 – 127	ND – 28.3	27.4 - 63	ND – 422	ND	32.0 – 36.6	8.5 – 35.1	ND
Cyanide	ND	ND	ND – 0.39	ND	ND	ND – 2.04	ND	ND	ND – 0.69

NOTE: Source: Mitchell and Weiss (1995). All radionuclide values reported in pCi/g; all nonradionuclide values reported in mg/kg dry weight.
NA = not analyzed
ND = not detected
B Pond: 4 soil samples, 4 vegetation samples, 6 animal samples
216-T-4 Ditch: 4 soil samples, 4 vegetation samples, 6 animal samples
Control site: 2 soil samples, 5 vegetation samples, 4 animal samples

Table 3-5. List of Contaminants of Concern at the 200-TW-1 Operable Unit.

Radioactive Constituents	
Americium-241	Plutonium-239/240
Carbon-14	Radium-226
Cesium-137	Radium-228
Cobalt-60	Strontium-90
Europium-152	Technetium-99
Europium-154	Tritium
Europium-155	Thorium-232
Neptunium-237	Uranium-233/234
Nickel-63	Uranium-235/236
Plutonium-238	Uranium-238
Chemical Constituents – Metals	
Cadmium	Lead
Chromium	Mercury
Hexavalent chromium	Nickel
Copper	Silver
Chemical Constituents - Other Inorganics	
Ammonia/ammonium	Nitrate/nitrite
Chloride	Phosphate
Cyanide	Sulfate
Fluoride	
Semi-Volatile Organics	
AMSCO[a]	Normal paraffin hydrocarbon[a]
Dodecane[a]	Tributyl phosphate and derivatives (mono, bi)

[a]Analyzed as kerosene total petroleum hydrocarbons.

Table 3-6. List of Contaminants of Concern at the 200-TW-2 Operable Unit.

Radioactive Constituents	
Americium-241	Plutonium-239/240
Carbon-14	Radium-226
Cesium-137	Radium-228
Cobalt-60	Strontium-90
Europium-152	Technetium-99
Europium-154	Tritium
Europium-155	Thorium-232
Neptunium-237	Uranium-233/234
Nickel-63	Uranium-235/236
Plutonium-238	Uranium-238
Chemical Constituents – Metals	
Cadmium	Lead
Chromium	Mercury
Hexavalent chromium	Nickel
Copper	Silver
Chemical Constituents - Other Inorganics	
Ammonia/ammonium	Nitrate/nitrite
Chloride	Phosphate
Cyanide	Sulfate
Fluoride	

4.0 WORK PLAN APPROACH AND RATIONALE

4.1 SUMMARY OF DATA QUALITY OBJECTIVE PROCESS

The RI needs for the 200-TW-1 and 200-TW-2 OUs were developed in accordance with the DQO process (EPA 1994a; BHI-EE-01, *Environmental Investigations Procedures*, Procedure 1.2). The DQO process is a seven-step planning approach that is used to develop a data collection strategy consistent with data uses and needs. The goals of the process are to provide the data needed to refine the preliminary conceptual contaminant distribution model and support remedial decisions.

The DQO process was implemented by a team of subject matter experts and key decision makers. Subject matter experts provided input on regulatory issues, the history and physical condition of the sites, and sampling and analysis methods. Key decision makers from DOE, Ecology, and the EPA participated in the process to develop the characterization approach outlined in the DQO summary report. The DQO process and involvement of the team of experts and decision makers provides a high degree of confidence that the right type and quality of data are collected to fulfill informational needs of the 200-TW-1 and 200-TW-2 decisional process. Results of the DQO process for characterization of the representative sites in the 200-TW-1 and 200-TW-2 OUs are presented in the *DQO Summary Report for the 200-TW-1 Scavenged Waste Group Operable Unit and 200-TW-2 Tank Waste Group Operable Units* (BHI 2000). During the DQO, it was determined that the characterization data previously obtained for the 216-B-46 Crib are sufficient to support the 200-TW-1 RI/FS process. In addition, radiological data from the 216-B-5 Reverse Well are considered sufficient to support the 200-TW-2 RI/FS process; nonradiological data to be collected from the 216-B-7A/B Cribs are considered analogous to the 216-B-5 Reverse Well and will be used to complete the RI/FS process at 216-B-5. However, geophysical logging of nearby boreholes for each of these sites will be conducted as an efficient means to provide additional data to support refinement of the preliminary conceptual contaminant distribution models. Characterization activities outlined in this work plan focus on the 216-T-26 Crib for the 200-TW-1 OU and the 216-B-7A/B Cribs and the 216-B-38 Trench for the 200-TW-2 OU.

Because these OUs are in close proximity to the tank farms and because of the nature of the contaminants disposed, other Hanford Site projects would benefit from data collected for RI purposes. Integration activities with the DOE, Office of River Protection, and the DOE, Richland Operations Office, included development of contaminants of potential concern and analytical requirements, selection of representative waste sites, and core project-specific data collection needs, which have been incorporated into the SAP. Representatives from both DOE offices as wells as contractor personnel from the various core projects were involved in the DQO for this work plan; elements from the integrated DQO have been incorporated into the work plan and SAP. The 200 Area Remedial Action Project also provided input into the DQO processes for activities at the B-BX-BY and T-TX-TY Tank Farm vadose projects. Data collected under this work plan will be used by other Hanford Site projects as appropriate to their particular needs.

The nature of the waste sites to be investigated in the RI support the use of focused sampling as identified in *Washington State Department of Ecology Toxics Cleanup Program Guidance on Sampling and Data Analysis Methods* (Ecology 1995). This guidance document defines focused sampling as selective sampling of areas where potential or suspected soil contamination can reliably be expected to be found if a release of a hazardous substance has occurred. The relatively small crib structures to be investigated released contaminants in a point-source fashion. Contaminants released through a small crib would likely impact the soil immediately beneath the crib with minimal lateral spread; therefore, focusing the RI sampling through the crib will ensure collection of the area of greatest impact associated with the discharge. Contaminant distributions are expected to follow relatively predictable patterns based on process knowledge and existing environmental data. Even though the 216-B-38 Trench is somewhat larger than the cribs identified for RI, it is still a relatively small site. Additional efforts may be needed to determine the worst-case location for the borehole within the trench; these will provide additional data on gamma-emitting radionuclides to support the focused sampling regime.

4.1.1 Data Uses

Data generated during characterization of the representative sites will consist mainly of soil contaminant data. These contaminant data will be used along with existing data from the 216-B-46 and 216-B-5 representative sites to define the nature and vertical extent of radiological and chemical contamination, support an initial evaluation of potential human health risks, and assist in the evaluation and selection of a remedial alternative. By defining the type and vertical distribution of contamination, the conceptual model for contaminant distribution can be verified or refined. The lateral extent of contamination is assumed to be confined within the site boundaries but may be evaluated through geophysical logging results. Additional evaluation of the lateral extent of contamination will be done during the confirmatory sampling phase as necessary to support remedial design. Verification of the current conceptual contaminant distribution models will direct the application of the analogous site concept at the remaining 200-TW-1 and 200-TW-2 waste sites. A limited amount of data will be collected to characterize the physical properties of soils that will be used to support an initial assessment of risk (e.g., RESidual RADioactivity [RESRAD] dose model or other risk modeling, as required). Contaminant and soil property data will be obtained by sampling and analyzing soils.

4.1.2 Data Needs

A considerable amount of information has been presented in Sections 2.0 and 3.0 regarding the 200-TW-1 and 200-TW-2 OU waste sites. Existing data were sufficient to develop an understanding of radiological and chemical contaminant distribution for the 216-B-46 Crib and radiological contaminant distribution for the 216-B-5 Reverse Well. However, the existing data are insufficient to develop a distribution model for the other three representative sites. The most pertinent existing information was used to develop site-specific conceptual contaminant distribution models for the 216-T-26, 216-B-7A/B, and 216-B-38 waste sites; additional information is provided by reference. For the representative waste sites (and the other waste sites in the OU in general), information is available regarding location, construction design, and major types of waste disposed. For several of the sites (those associated with 200-BP-1 investigation activities and the 216-B-5 Reverse Well), considerable data exist. However, the

data needed to verify and/or refine the site conceptual models at 216-T-26, 216-B-7A/B, and 216-B-38 and to develop contaminant distribution models are limited. These data are needed to support remedial decision making at these sites and any analogous sites. As defined by the DQO process, the focus of the 200-TW-1 and 200-TW-2 RIs is to determine the nature and extent of contamination in the vadose zone within the boundary of the representative waste sites. Specifically, determinations of the type, concentration (particularly the highest concentration), and vertical distribution of radiological and chemical contamination in the vadose zone at the 216-T-26, and 216-B-7A/B Cribs and 216-B-38 Trench are the major data needs. Data are also required to determine the physical properties of soils; these data will provide additional inputs to support an evaluation of risk through the use of models for fate and transport of contaminants through the vadose zone to groundwater, exposure to radionuclides, and exposure to chemicals.

4.1.3 Data Quality

Data quality was addressed during the DQO session. The data quantity and quality for the 216-B-46 Crib were determined to be sufficient to support the RI/FS process. The COCs were identified for this site based on data previously collected under an approved work plan. The radiological data quantity for 216-B-5 Reverse Well was determined to be sufficient to support the RI/FS process. The quality of the data for 216-B-5 is not necessarily in line with the requirements of the DQO. However, the 216-B-5 and 216-B-7A/B sites received the same waste stream. The data for 216-B-5 will be augmented with data collected for the 216-B-7A/B Cribs. This will provide sufficient quantity and quality for the RI/FS process at 216-B-5 without any additional sampling at the reverse well.

The process of identifying potential COCs is summarized in Section 3.5. Analytical performance criteria were established by evaluating potential ARARs and preliminary remediation goals (PRGs), which are regulatory thresholds and/or standards or derived risk-based thresholds. These potential ARARs and PRGs represent chemical-, location-, and action-specific requirements that are protective of human health and the environment. Regulatory thresholds and/or standards or preliminary action levels provide the basis for establishing cleanup levels and dictate analytical performance levels (i.e., laboratory detection limit requirements). Detection limit requirements and standards for precision and accuracy are used to define data quality.

To provide the necessary data quality, detection limits should be lower than preliminary action levels. Additional data quality is gained by establishing specific policies and procedures for the generation of analytical data and field quality assurance/quality control requirements. These requirements are discussed in detail in the SAP (Appendix A). Analytical performance requirements are specified in Table 3-6 of the DQO summary report (BHI 2000). The potential ARARs and PRGs for 200 Area waste sites are discussed in Sections 4.0 and 5.0 of the Implementation Plan (DOE-RL 1999).

4.1.4 Data Quantity

Data quantity refers to the number of samples collected. The number of samples needed to refine the site conceptual model and make remedial decisions is based on a biased sampling

approach. Biased sampling is the intentional location of a sampling point within a waste site based on process knowledge of the waste stream and expected behavior of the potential COC(s). It is the preferred sampling approach as defined in Section 6.2.2 of the Implementation Plan (DOE-RL 1999) for the RI phase. Using this approach, sampling locations can be selected that increase the chance of encountering the highest contamination in the local soil column.

Sample locations at the representative sites were selected based on the preliminary conceptual models of contaminant distribution presented in the DQO summary report (BHI 2000). Three sampling locations in three representative sites were selected for sampling. The locations were selected with the goal of intersecting the highest areas of contamination and to determine the type and vertical extent of contamination at the representative sites. Because the cribs being investigated cover only small areas, lateral extent of contamination within the site boundary is not considered necessary for remedial decision making. For the 216-B-38 Trench, lateral extent of contamination within the site boundaries will be evaluated with a borehole and augmented with geophysical logging of additional cased or direct push holes. Soil samples will be taken at each representative site from a deep borehole (to near the groundwater table) and will be collected from different depths at the waste site to evaluate the vertical extent of contamination. Extra soil samples may be collected as warranted by observations such as changes in lithology, visual indications of contamination, and field screening results. This biased sampling approach was designed to provide the data needed to meet DQOs for this phase of the RI/FS process.

4.2 CHARACTERIZATION APPROACH

This section provides an overview of characterization activities that are planned to collect the required data identified in the DQO process. These activities include borehole drilling and sampling and geophysical logging using spectral gamma and neutron moisture tools. Sample analysis will be conducted by an offsite laboratory under a contract-required quality program. The sampling strategy is designed to provide access to potentially contaminated subsurface areas. Sample collection will be guided by field screening and a sampling scheme that identifies critical sampling depths.

The sample above the water table is intended to represent deep contaminants in the vadose zone that could potentially impact groundwater. The sample intervals are also significant at the 4.6- and 7.6-m (15- and 25-ft) depth to define contamination profiles for remedial designs. For excavation and disposal sites, the decision-making depth is 4.6 m (15 ft), as directed by *Model Toxics Control Act* (MTCA) direct exposure requirements. For containment sites, models show that RCRA surface barriers become more cost effective than excavation in the 4.6- to 6.1-m (15- to 20-ft)-depth range.

4.2.1 Geophysical Logging Through Direct Push Holes

The location of the inlet to the 216-B-38 Trench is unknown; a review of existing drawings and literature did not yield sufficient information to identify the inlet, or area of highest potential contamination within in the trench. Therefore, locating the borehole for this site requires some preliminary geophysical logging activities to target the area of highest contamination. A series

of up to five direct push (e.g., GeoProbe or cone penetrometer) holes will be installed and logged with a spectral gamma tool. The location of the borehole will be identified based on the results of this logging. The depth of direct push holes is limited based on subsurface conditions (i.e., cobbles, gravel). The holes will be pushed as deep as possible, but a maximum depth of approximately 9 m (30 ft) bgs is assumed for investigation planning. If contamination extends beyond this depth, additional casings may be driven into the subsurface to allow geophysical logging of deeper zones in this trench (see Section 4.2.2).

4.2.2 Drilling and Sampling

The 216-T-26 Crib and 216-B-7A Crib boreholes will be drilled and sampled from locations near the center of each crib to a depth just above the groundwater table (Figures 4-1 and 4-2). The 216-B-38 Trench deep borehole will be located near the direct push hole with the maximum indication of contamination based on the geophysical logging as described in Section 4.2.1 (Figure 4-3). These locations were chosen to target the areas of maximum contamination within each site. Therefore, the deep sediments that will be collected should provide a worst-case scenario for maximum contamination levels at depth.

The sample collection strategy has been designed to thoroughly characterize the vadose zone materials beneath the sites to the top of the groundwater table. Sampling will generally begin at the first sign of radiological contamination, as determined by field measurements. This contamination is expected to begin at the historic bottom of the site (i.e., crib or trench bottom), but if contamination is detected in backfill materials above the waste site bottom, the backfill materials will also be sampled. The 216-B-7A&B Cribs are known to have contamination above the crib structures associated with the consolidation of an unplanned release over the crib area. Borehole samples will typically be collected at a more frequent interval from the effluent release point (i.e., the bottom of the crib or trench), and then at decreasing frequency with depth. Samples that were identified as critical during the DQO process will be collected at 4.6 m (15 ft) bgs. A 7.6-m (25-ft) bgs sample will also be identified as critical for determining the cost effectiveness of placing a barrier over a waste site versus the excavation of contaminants. Additional samples may be collected at the discretion of the geologist/sampler based on field screening and geologic information (e.g., changes in lithology). A detailed sample schedule for each borehole is presented in the SAP (Appendix A).

All drilling will be via a procedure approved by Bechtel Hanford, Inc. (BHI), and will conform to site-specific technical specifications for environmental drilling services. The drill rig generally will require a 23-m (75-ft)-square pad with a 5-m (16-ft)-wide access road. Cleaning and decontamination requirements will also be performed according to BHI-approved procedures.

Likely drilling methods for this project include cable tool, sonic, and diesel hammer. The drilling method must allow the use of a 13-cm (5-in.) outside-diameter split-spoon sampler. Use of a split-spoon sampler will necessitate compositing the sample over at least 0.3 m (1 ft) to obtain enough sample for analysis. The drilling method must not use any system that circulates air or water. Air-based drilling methods may compromise the sample collection and data quality for volatile constituents through the introduction of air to the soils. Controlling contamination

with these methods is difficult, potentially increasing risks to workers. In addition, the air circulated in these methods may dry out the formation and negatively impact the moisture logging activities.

All three boreholes will be drilled to the top of the water table. The maximum total depth of the investigation below ground surface is approximately as follows: the 216-T-26 Crib will be 68 m (222 ft), the 216-B-7A Crib will be 78 m (255 ft), and the 216-B-38 Trench will be 76 m (250 ft). In the boreholes, the presence of water-saturated soils will indicate the end of the borehole and will be determined by the site geologist. Up to three strings of casing may be telescoped to the proposed depth to minimize the transport of contaminants in the vadose zone from the drilling operations. The casing sizes will be of sufficient size to accommodate a split-spoon sampler to the bottom of the borehole. Downsizing of the casing will be commensurate with the expected decrease in contamination levels with depth. Actual conditions during drilling may warrant changes; the changes may be implemented after consultation with and the approval of the task lead and the subcontract technical representative. All casings will be removed from the boreholes when drilling and sampling are completed. If required to support Hanford Site groundwater monitoring needs, boreholes may be completed as wells. Otherwise, the borehole will be backfilled with bentonite or an appropriate alternative abandonment procedure in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells."

4.2.3 Field Screening

All samples and/or cuttings from the boreholes will be field screened for evidence of radionuclides. Radioactivity screening of the soils will assist in the selection of sampling intervals (besides those already identified as critical sampling depths).

4.2.4 Analysis of Soil

Soil samples will be collected for nonradiological and radionuclide analysis and the determination of select soil properties. The list of analytes for this investigation was developed based on an evaluation of all potential contamination that was discharged to the waste sites. Development of this list of COCs is presented in Section 3.5, Tables 3-3 and 3-4, and in the DQO Summary Report (BHI 2000). Tables A-4 and A-5 of the SAP list details of the analytical methods, holding times, and quality assurance and quality control procedures for each contaminant. A limited number of samples will also be analyzed to determine soil physical properties, such as moisture content and particle size.

4.3 GEOPHYSICAL LOGGING

The three boreholes (described in Section 4.2.1) will be logged with a high-resolution spectral gamma-ray logging (SGL) system to provide continuous vertical logs of gamma-emitting radionuclides and with a neutron moisture-logging system to identify moisture changes. In addition to the logging performed on the new borings, SGL is proposed in existing wells near the 216-B-46, 216-T-26, 216-B-5, and 216-B-7A/B waste sites. Wells at the 216-B-38 Trench were

recently logged; data are reported in Horton and Randall (2000). The SGL of existing wells in the vicinity of a waste site can be a cost-effective method of providing supplemental data on the vertical and lateral distribution of gamma-emitting radionuclides, provided that the wells are located sufficiently close to the waste site and are appropriately constructed (e.g., single well casing in contact with the formation).

The SGL system uses standard laboratory HPGe detector instrumentation to identify and quantify gamma-emitting radionuclides in wells as a function of depth. The HPGe detector is calibrated to National Institute of Standards and Testing requirements and includes corrections for environmental conditions that deviate from the standard calibration condition. The HPGe detector has been used to locate, identify, and monitor the distribution and movement of contaminants in more than 600 boreholes at the Hanford Site. The precision of this detector is such that movement of mobile constituents in the subsurface can be identified to as little as 0.07 m (0.25 ft) at depths of up to 167.6 m (550 ft). The detector requires constant cooling with liquid nitrogen and was designed to operate completely submerged in water. Venting of the nitrogen gas to the surface is accomplished with a specially designed logging cable.

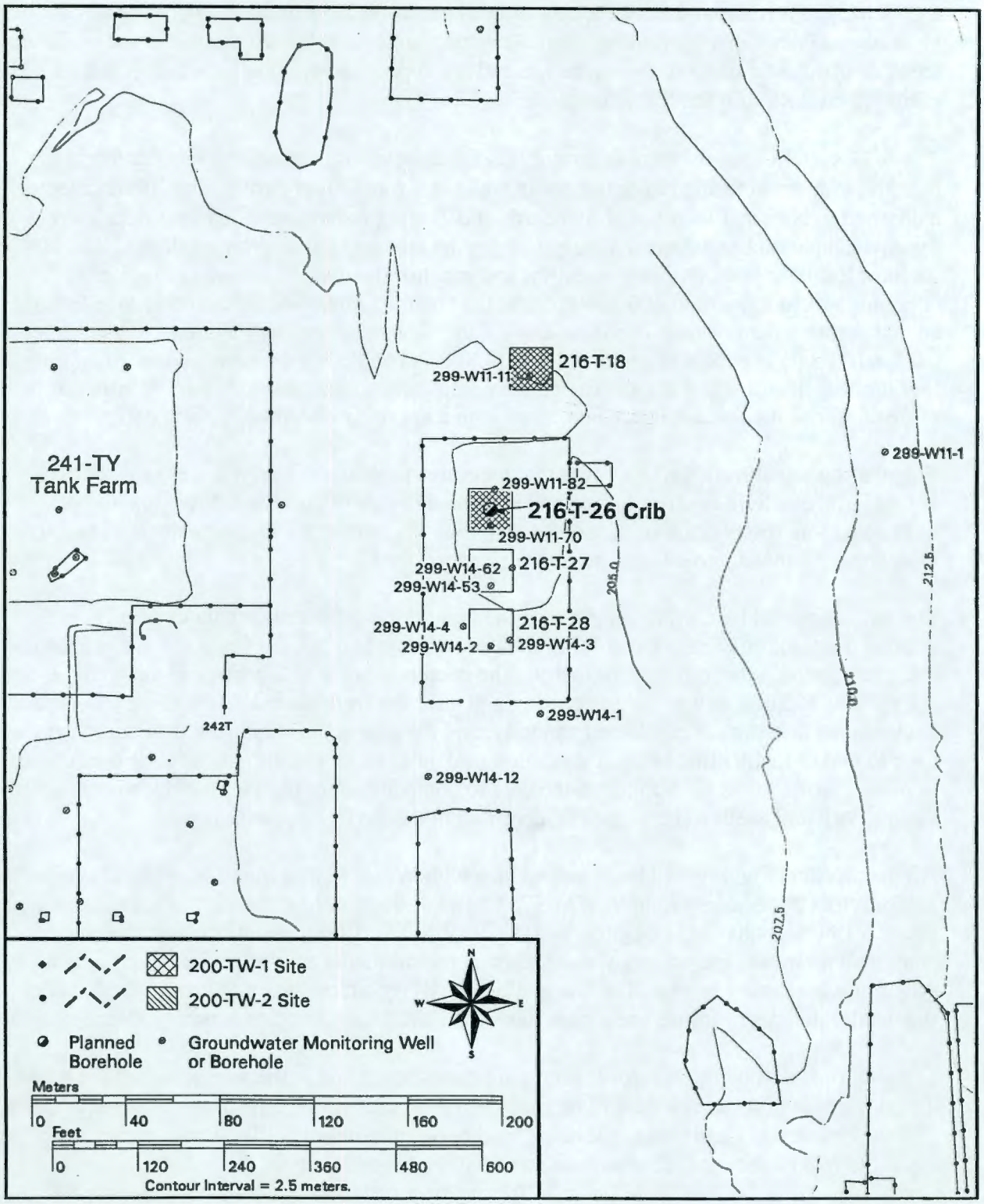
The neutron moisture-logging system that measures moisture employs a weak radioactive americium-beryllium neutron source and neutron detector to provide a direct reading of hydrogen atom distribution in the soil surrounding the borehole. This detector will be used to measure continuous vertical moisture in the vadose zone.

The SGL logs will be used to supplement the laboratory radionuclide data to determine the vertical distribution of radionuclides in the vadose zone beneath the units and aid in geological interpretation of subsurface stratigraphy. The deep boreholes will be logged through the casing prior to the addition of a new casing string and after the well has reached total depth. The SGL equipment calibration is conducted annually, and the data acquired during the calibrations are used to derive factors that convert measured peak area count rate to radionuclide concentrations in pCi/g. Corrections are applied to the data to compensate for the gamma-ray attenuation by the casing. A list of wells to be logged is identified in the SAP (Appendix A).

All geophysical logging will be in accordance with Waste Management Northwest's *Sampling and Services Procedure Manual,* WMNW-CM-004, Section 17 ("Geophysical Logging"), and Section 18 ("Geophysical Logging Analysis") (WMNW 1998). Applicable detection limits, analytical methods, and accuracy and precision requirements are defined in the documents governing borehole logging. The site geologist will record the types of geophysical surveys and the depth intervals of initial and repeat runs in the Well Construction Summary Report form.

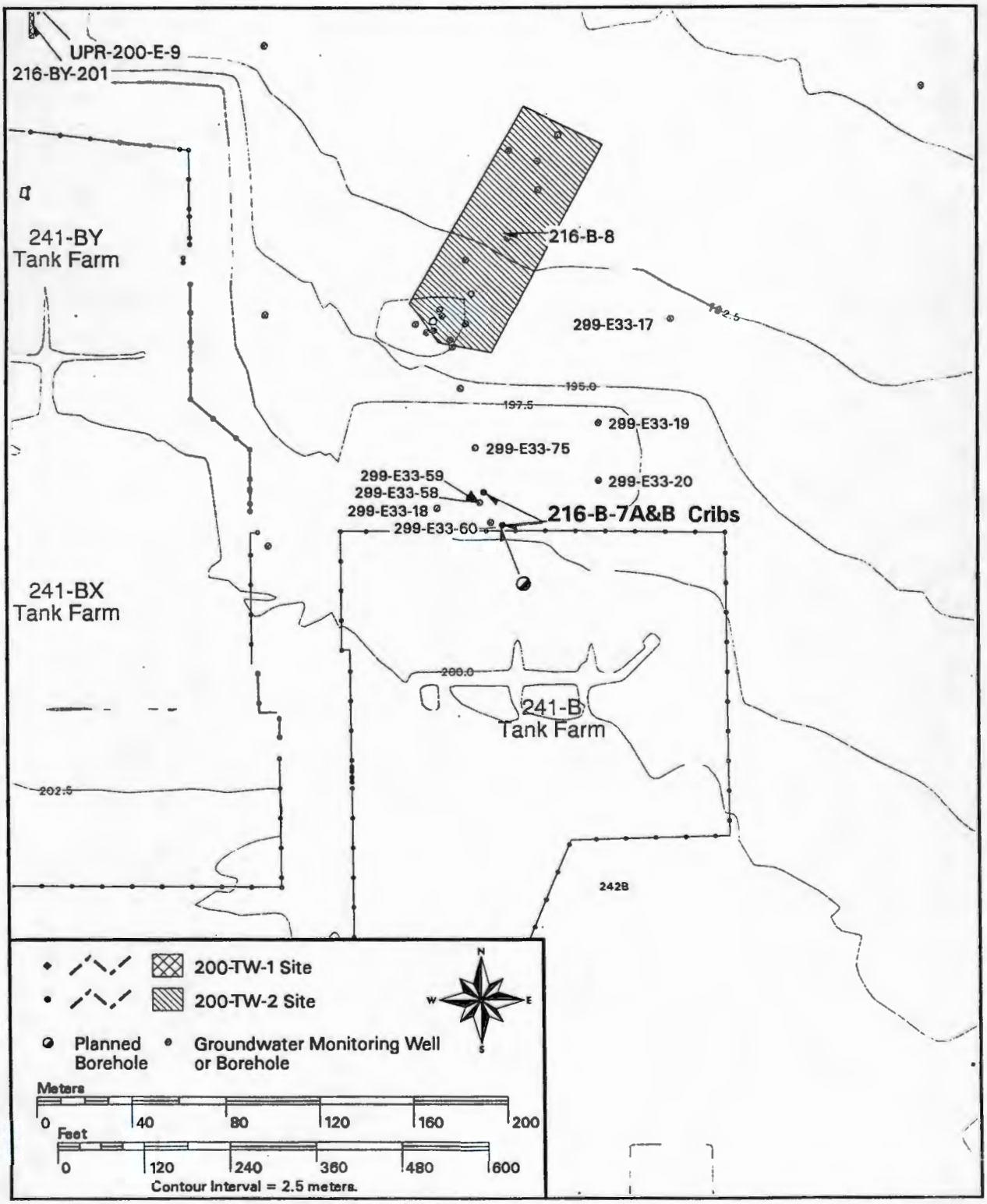
Logging runs will be made prior to changing casing sizes and at the total depth of the borehole. The downhole tools and cable will be subject to the same rules as the drill rig and equipment. The downhole tools and cable will be cleaned between boreholes. The upper part of each borehole will be the most contaminated and will be logged first.

Figure 4-1. Sample Location Map for the 216-T-26 Crib.



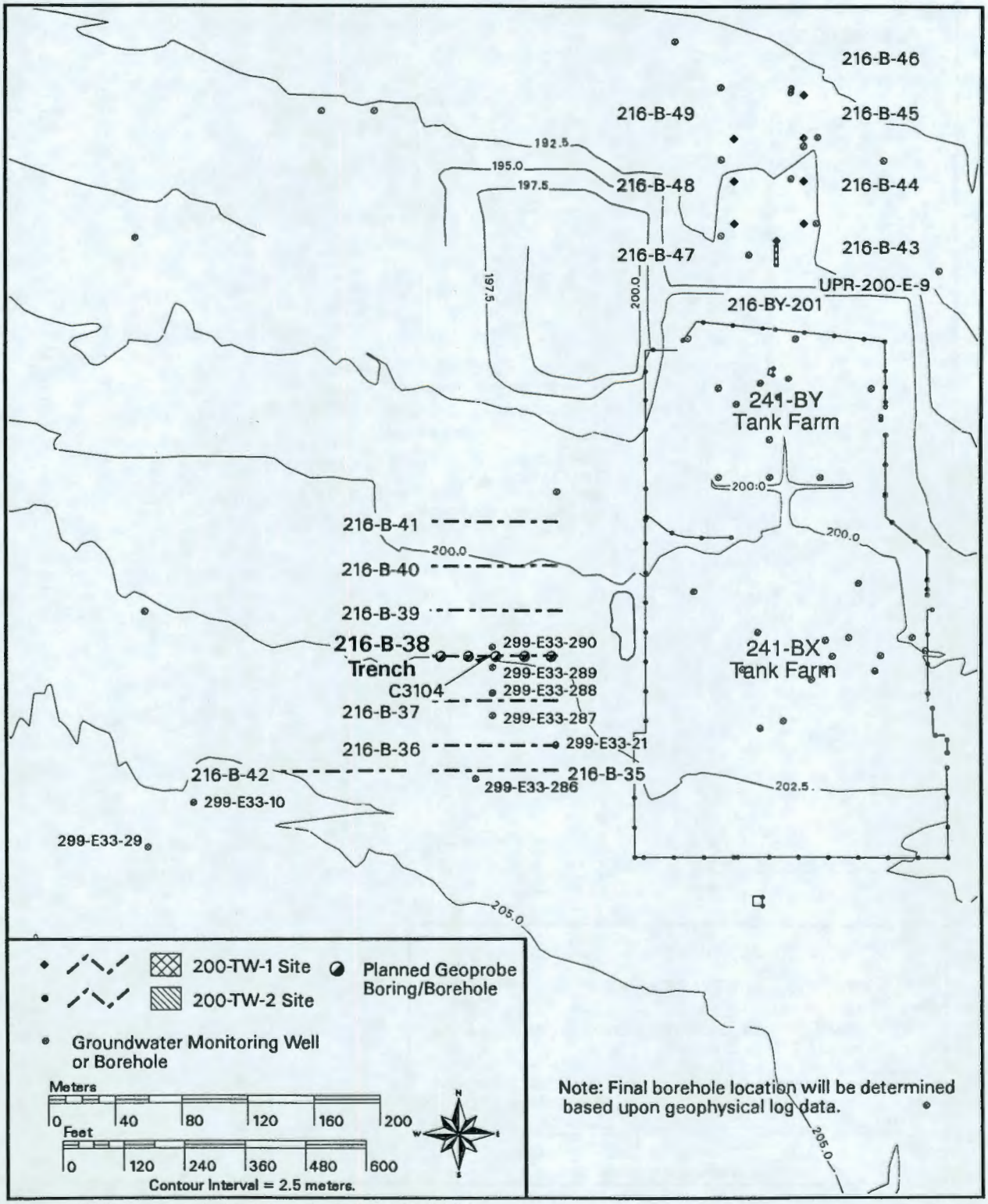
BHI:maa 1/10/00 /home/maaye/amls/ws516_a.aml Database: 15-MAY-2000

Figure 4-2. Sample Location Map for the 216-B-7A&B Cribs.



BHI:maa 01/10/00 /home/maaye/amls/ws449_a.aml Database: 15-MAY-2000

Figure 4-3. Sample Location Map for the 216-B-38 Trench.



BHI:maa 01/05/00 /home/maaye/amls/ws414_a.aml Database: 22-FEB-2001

5.0 REMEDIAL INVESTIGATION/FEASIBILITY STUDY PROCESS

This section describes the RI/FS (assessment) process for the 200-TW-1 OU and the RFI/CMS (assessment) process for the 200-TW-2 OU. The development of and rationale for these processes are provided in the Implementation Plan (DOE-RL 1999) and are summarized in Figure 1-1. The process for both OUs will follow the CERCLA format with modifications to concurrently satisfy the requirements specific to RPP waste sites. The CERCLA terminology will be used as described in the Implementation Plan. A summary of the integrated regulatory process is provided in Section 5.1.

Section 5.2 outlines the tasks to be completed during the RI phase, including planning and conducting field sampling activities and preparation of the RI report. These tasks are designed to effectively manage the work, satisfy the DQOs identified in Section 4.0, document the results of the investigation, and manage waste generated during field activities. The general purpose of the RI is to characterize the nature, the vertical extent, and in some cases the lateral extent within the confines of the waste site; concentration; and potential transport of contaminants and to provide data to determine the need for and type of remediation. The detailed information that will be collected to carry out these tasks is presented in the SAP (Appendix A). This work plan covers both the 200-TW-1 and 200-TW-2 OUs; however, future activities, such as the RI, RI report, and FS, may be conducted either separately for each OU or combined for both OUs.

Tasks to be completed following the RI include an FS, a proposed plan, and a ROD. A proposed permit modification will also be prepared for the 200-TW-2 OU. The RCRA permit will be modified to incorporate the ROD (and any subsequent amendments) by reference, authorizing the RCRA actions at the 200-TW-2 OU.

Project management occurs throughout the RI/FS process. Project management is used to direct and document project activities so that objectives of the work plan are met and the project is kept within budget and schedule goals. The initial project management activity will be to assign individuals to roles established in Section 7.2 of the Implementation Plan (DOE-RL 1999). Other project management activities include day-to-day supervision of and communication with project staff and support personnel; meetings; control of cost, schedule, and work; records management; progress and final reports; quality assurance; health and safety; and community relations.

Appendix A of the Implementation Plan (DOE-RL 1999) provides the overall quality assurance framework that was used to prepare an OU-specific quality assurance project plan for the RI (Appendix A, Section A.2). Appendix B of the Implementation Plan includes a review of data management activities that are applicable to the investigation activities at these OUs and describes the process for the collection/control of data, records, documents, correspondence, and other information associated with OU activities.

5.1 INTEGRATED REGULATORY PROCESS

RCRA closure and corrective action authorities have clear jurisdiction over waste with nonradiological constituents (in particular, dangerous waste and dangerous constituents) and "mixed wastes" (mixtures of dangerous waste and radiological contaminants), but not over waste with radiological contaminants only. By applying CERCLA authority concurrently with RCRA corrective action requirements through integration, cleanup actions will address all regulatory and environmental obligations at these OUs as effectively and efficiently as possible. Also, by applying CERCLA authority jointly with that of RCRA, additional options for disposal of corrective action and remedial action wastes at the Environmental Restoration Disposal Facility are possible. By allowing flexibility in final disposal options, the Tri-Parties intend to minimize disposal costs as much as possible while remaining fully protective of human health and the environment.

The integrated process for characterization of the 200-TW-1 and 200-TW-2 OUs uses this RI/FS work plan in combination with the Implementation Plan (DOE-RL 1999) to satisfy the requirements for both an RI/FS work plan and an RFI/CMS work plan. General facility background information, potential ARARs, preliminary RAOs, and preliminary remedial technologies developed in the Implementation Plan are incorporated by reference into this work plan. Following the completion of the work plan, an RI will be performed that will satisfy the requirements of a RCRA RFI. The RI will be limited to the investigation of representative waste sites. An RI report summarizing the results of the RI will then be prepared that will satisfy the requirements for an RFI report.

After the RI is complete, remedial alternatives/corrective actions will be developed and evaluated against performance standards and evaluation criteria. The integration process for the evaluation of remedial alternatives includes the preparation of an FS that will satisfy the requirements for a CMS report. Both documents are required to include identification and development of corrective measure/remedial alternatives and an evaluation of those alternatives. The CMS generally also includes a recommended alternative, which is typically the purpose of the proposed plan under CERCLA. Therefore, the FS for 200-TW-2 will include a section that provides corrective action recommendations for RPP sites.

The decision-making process for the 200-TW-1 and 200-TW-2 OU, as defined in the Implementation Plan, will be based on the use of a proposed plan and a ROD. Based on the group-specific FS, a proposed plan will be prepared that identifies the preferred remedial alternative for waste sites within the OU. The lead regulatory agency (EPA for the 200-TW-1 OU and Ecology for the 200-TW-2 OU) will prepare the CERCLA ROD following completion of the public involvement process for the proposed plan and the proposed permit modification, which, after signature by the Tri-Parties, will authorize the selected remedial action. The remedy selected in the ROD will be incorporated into the Hanford Facility RCRA Permit as the corrective action for 200-TW-2 after issuance of the public notice and comment process.

The technical and procedural elements of RCRA and CERCLA are each addressed in full in this process. The CERCLA public involvement, including public notice and opportunity to comment, will be enhanced, as necessary, to concurrently satisfy the public involvement

requirements for the RCRA past-practice process. The public will be given an opportunity to review and comment on the proposed plans and the proposed permit modifications. The proposed plans will be issued for a minimum 45-day public review and comment period. Supporting documents, including the FS, will also be made available to the public for review at this time. A combined public meeting/public hearing may be held during the comment period to provide information on the proposed action and permit modification and to solicit public comment.

5.2 REMEDIAL INVESTIGATION ACTIVITIES

This section summarizes the planned tasks that will be performed during the RI phase for the 200-TW-1 and 200-TW-2 OUs, including the following:

- Planning
- Field investigation
- Management of investigation-derived waste (IDW)
- Laboratory analysis and data verification
- Data evaluation and reporting.

These tasks and subtasks reflect the work breakdown structure that will be used to manage the work and to develop the project schedule provided in Section 6.0.

5.2.1 Planning

The planning subtask includes activities and documentation that need to be completed before field activities can begin. These include the preparation of an activity hazards analysis and site-specific health and safety plan (HASP), radiation work permits, excavation permits and supporting surveys (e.g., cultural, radiological, wildlife, and utilities), work instructions, personnel training, and the procurement of materials and services (e.g., drilling and geophysical logging services). In addition, boreholes identified in Figures 4-1 through 4-3 will be located using a Global Positioning Satellite system.

Appendix B of the Implementation Plan (DOE-RL 1999) provides a general HASP that outlines health and safety requirements for RI activities. A site-specific HASP will be prepared for drilling activities, following requirements of the general HASP. Initial surface radiological surveys will be performed to document any radiological surface contamination and background levels in and around the sampling locations. This information will be used to document initial site conditions and prepare the HASP and radiation work permits.

5.2.2 Field Investigation

The field investigation task involves data-gathering activities performed in the field that are required to satisfy the project DQOs. The field characterization approach is summarized in Section 4.2 and detailed in the SAP provided in Appendix A of this work plan. The scope

includes soil/sediment sampling and analysis to characterize the vadose zone at the 200-TW-1 OU representative waste site (216-T-26 Crib [216-B-46 Crib was characterized as part of the 200-BP-1 OU; no additional sampling is proposed at this location]) and the 200-TW-2 OU representative sites (216-B-7A/B Cribs and 216 B-38 Trench [216-B-5 was characterized for radiological constituents in 1980; no additional sampling is proposed at this location]). Major subtasks associated with the field investigation include the following:

- Borehole drilling, sampling, and associated geophysical logging
- Preparation of field reports.

5.2.2.1 Borehole Drilling and Sampling. This subtask involves the drilling of boreholes for the purpose of collecting soil and sediment samples and geophysical logging of new and existing boreholes. For the 200-TW-1 OU, one borehole is planned to collect samples down to the top of the groundwater table through the center of the 200-T-26 Crib. For the 200-TW-2 OU, one borehole is planned for the 216-B-7A Crib to the top of the groundwater table. Additionally, one borehole is planned for the 216-B-38 Trench. A borehole near the inlet or the most contaminated area of the trench as identified by geophysical logging of direct push holes will be drilled to the top of the groundwater table. Casings may be driven in up to five additional locations for geophysical logging to provide additional information on the distribution of gamma-emitting radionuclides within the boundary of the trench.

Samples will be collected with split-spoon samplers and packaged for shipment to an offsite laboratory if radiation levels permit. Otherwise, samples will be shipped to an onsite laboratory. At the completion of sampling, the boreholes will be abandoned and initial site conditions reestablished. Alternatively, the boreholes may be completed as groundwater monitoring wells, if needed by the Hanford Site groundwater monitoring program. Other activities include work zone setup, mobilization/demobilization of equipment, equipment decontamination, and field analyses. Planned field analyses include radiological field screening, geologic logging, and geophysical logging of boreholes.

All samples and drill cuttings will be field screened for radionuclides to provide additional characterization data, assist in the selection of sample intervals (e.g., hot spots), assist in establishing radiation control measures, and ensure worker health and safety.

Geophysical logging will be used to gather in situ radiological and physical data from the borehole and from several existing wells (specified in Table A-11 of the SAP). Spectral gamma-ray logging will be performed to assess the distribution of gamma-emitting radionuclides, and neutron logging will be performed for moisture content distribution over the borehole or well interval.

5.2.2.2 Preparation of Field Reports. At the completion of the field investigation, a field report (or reports) will be prepared to summarize activities performed and information collected in the field, including survey data for borehole locations, the number and types of samples collected and associated Hanford Environmental Information System numbers, inventory of IDW containers, geological logs, field screening results, and geophysical logging results.

5.2.3 Management of Investigation-Derived Waste

Waste generated during the RI will be managed in accordance with a waste control plan to be prepared for the OU. Appendix E of the Implementation Plan (DOE-RL 1999) provides general waste management processes and requirements for this IDW and forms the basis for activity-specific waste control plans. The site-specific waste control plan addresses the handling, storage, and disposal of IDW generated during the RI phase. Furthermore, the plan identifies governing Environmental Restoration Contractor procedures and discusses types of waste expected to be generated, the waste designation process, and the final disposal location. The IDW management task begins at the start of the field investigation, when IDW is first generated, through waste designation and disposal.

5.2.4 Laboratory Analysis and Data Validation

Soil and sediment samples collected via boreholes will be analyzed for a suite of radionuclides and chemicals identified during the DQO, and for select physical properties based on established DQOs and as defined in the SAP. The list of analytes, methods, and associated target detection limits are provided in Tables A-4 and A-5 of the SAP. This task includes the laboratory analysis of samples, the compilation of laboratory results in data packages, and the validation of a representative number of laboratory data packages.

5.2.5 Remedial Investigation Report

This section summarizes data evaluation and interpretation subtasks leading to the production of an RI report. The primary activities include a data quality assessment (DQA); evaluating the nature, extent, and concentration of contaminants based on sampling results; assessing contaminant fate and transport; refining the site conceptual models; and evaluating risks through a qualitative risk assessment (QRA). These activities will be performed as part of the RI report preparation task.

5.2.5.1 Data Quality Assessment. A DQA will be performed on the analytical data to determine if they are the right type, quality, and quantity to support their intended use. The DQA completes the data life cycle of planning, implementation, and assessment that began with the DQO process. In this task, the data will be examined to see if they meet the analytical quality criteria outlined in the DQO and are adequate to evaluate the decision rules in the DQO.

5.2.5.2 Data Evaluation and Conceptual Model Refinement. This task will include evaluating the information collected during the investigation. The nonradiological and radiological data obtained from the boreholes will be compiled, tabulated, and statistically evaluated to gain as much information to satisfy the data needs as possible. Data evaluation tasks may include the following:

- Graphically evaluating the data for vertical distribution of contamination within each borehole.

- Stratifying the data and computing basic statistical parameters such as mean and standard deviation for individual levels. This can provide an indication of contaminant distribution.

- Constructing contour diagrams and variograms to evaluate spatial correlations within each stratum. This will indicate if contamination is concentrated in a particular area (e.g., near the influent end for trenches).

- Performing statistical tests on the data to evaluate the presence or absence of contamination. There are many facets to this step, including determining the distribution of the data and selecting the appropriate statistical tests. The initial screening for contamination should evaluate the data with respect to background, by using simple comparisons of an upper bound of the data to background concentrations (e.g., MTCA tests), or through more complex comparisons, such as nonparametric hypothesis tests (e.g., Wilcoxon Rank Sum Test). These tests may also compare the data to appropriate cleanup levels.

All of these statistical evaluations will aid in refining the conceptual model for these OUs and selecting the remedial alternative. However, because the sites within these OUs represent point-source type releases, statistical analysis may not always be possible. Single boreholes are planned at the sites. If the data are not sufficient for statistical analysis, maximum or average concentrations will be used in the data evaluation process.

Data on the soil physical properties will be used to determine the sediment type, which will assist in choosing the proper unsaturated hydraulic conductivity/moisture retention curve. Identification of the soil type and soil moisture will allow the determination of unsaturated hydraulic conductivity, which will be used as needed in modeling flow and transport (see Section 5.2.5.3).

The chemical, physical, and geophysical data will be used for correlating subsurface data, for further refinement of the preliminary conceptual contaminant distribution models, and as inputs to a QRA.

5.2.5.3 Qualitative Risk Assessment. The application of risk assessment in the characterization and remediation of the 200 Areas will follow a graded approach as described in Section 5.5 of the Implementation Plan. A QRA will be performed as part of the RI report and FS. Once additional data are available for all the sites in an OU, a more quantitative risk assessment may be performed. A quantitative, cumulative risk assessment will be used to evaluate remedial actions and close out the sites in the 200 Areas.

For the 200-TW-1 and 200-TW-2 OUs, QRAs will be prepared to evaluate risk to human receptors from potential exposure to contaminants in accessible surface sediments and shallow subsurface soils. The QRAs will also evaluate the impact to groundwater that may result from contaminants migrating to the water table through the vadose zone underlying wastes sites in these OUs.

The computer program RESRAD will be used to model radionuclide dose and impact to groundwater from radionuclides. The physical characterization data obtained in this study will

be used in RESRAD along with input parameters appropriate to the land use. As waste sites within both the 200-TW-1 and 200-TW-2 OUs are inside the 200 Area boundary, QRAs will be done for industrial land use. The input parameters recommended by the Washington State Department of Health (WDOH 1997) may be used for this effort.

5.3 FEASIBILITY STUDY

After the RI is complete, remedial alternatives will be developed and evaluated against performance standards and evaluation criteria in the FS. The FS process consists of several steps:

1. Defining RAOs and RCRA corrective action performance standards
2. Identifying general response actions (GRAs) to satisfy RAOs.
3. Identifying potential technologies and process options associated with each GRA.
4. Screening process options to select a representative process for each type of technology based on their effectiveness, implementability, and cost.
5. Assembling viable technologies or process options into alternatives representing a range of treatment, containment, and no action.
6. Evaluating alternatives and presenting information needed to support remedy selection.

Although some refinement is expected during the FS, Appendix D of the Implementation Plan satisfies the requirements for the screening phase (steps 1 through 6) of the FS process. The preliminary RAOs, PRGs, GRAs, and the screening-level analysis of alternatives is incorporated by reference into this work plan. As a result of the work completed in the Implementation Plan, the FS report will focus on the final phase of the FS consisting of refining and analyzing in detail a limited number of alternatives identified in the screening phase. Remedial action alternatives considered to be applicable to the 200-TW-1 and 200-TW-2 OUs include the following:

- No action alternative (no institutional controls)
- Engineered multimedia barrier
- Excavation and disposal of waste
- Excavation, ex situ treatment, and geologic disposal of TRU soil
- In situ vitrification of soil
- In situ grouting or stabilization
- Monitored natural attenuation (with institutional controls).

During the detailed analysis each alternative will be evaluated against the following CERCLA criteria (40 CFR 300.430):

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance.

One additional modifying criterion, community acceptance, will be applied following the FS at the proposed plan and ROD phase.

National Environmental Policy Act of 1969 (NEPA) values will also be evaluated as part of DOE's responsibility under this authority. NEPA values include impacts to natural, cultural, and historical resources; socioeconomic aspects; and, irreversible and irretrievable commitments of resources.

The RCRA corrective action performance standards (WAC 173-303-646[2]) will be used to evaluate alternative compliance with RCRA corrective action requirements. These standards state that corrective action must:

- Protect human health and the environment for all releases of dangerous wastes and dangerous constituents, including releases from all solid waste management units at the facility

- Occur regardless of the time at which waste was managed at the facility or placed in such units and regardless of whether such facilities or unit were intended for the management of solid or dangerous waste

- Be implemented by the owner/operator beyond the facility boundary, where necessary to protect human health and the environment.

The FS will also include supporting information needed to complete the detailed analysis and meet regulatory integration needs, including the following:

- Summarize the RI, including the nature and extent of contamination, the contaminant distribution models, and an assessment of the risks to help establish the need for remediation and to estimate the volume of contaminated media

- Refine the conceptual exposure pathway model to identify pathways that may need to be addressed by remedial action

- Provide a detailed evaluation of ARARs, starting with potential ARARs identified in the Implementation Plan (Section 4.0, DOE-RL 1999)

- Refine potential RAOs and PRGs identified in the Implementation Plan (Section 5.0, DOE-RL 1999), based on the results of the RI, ARAR evaluation, and current land-use considerations

- Refine the list of remedial alternatives identified in the Implementation Plan (Appendix D, DOE-RL 1999), based on the RI

- Provide corrective action recommendations for RPP sites to fulfill the requirements for a CMS report.

5.4 PROPOSED PLAN AND PROPOSED RCRA PERMIT MODIFICATION

The decision-making process for the 200-TW-1 and 200-TW-2 OUs will be based on the use of a proposed plan, ROD, and modification to the RCRA Hanford Facility Permit. Following the completion of the FS, a proposed plan will be prepared that identifies the preferred remedial alternative for the OUs (which will include RCRA corrective action requirements). In addition to identifying the preferred alternative, the proposed plan will:

- Provide a summary of the completed RI/FS

- Provide criteria by which analogous waste sites within the OU not previously characterized will be evaluated after the ROD to confirm that the contaminant distribution model for the site is consistent with the preferred alternative. Contingencies to move a waste site to a more appropriate waste group will also be developed

- Identify performance standards and ARARs applicable to the OU.

The proposed plan will also include a draft permit modification with unit-specific permit conditions for RPP sites for incorporation into the Hanford Facility RCRA Permit. After the public review process is complete, EPA as the lead regulatory agency for the 200-TW-1 OU and Ecology as the lead regulatory agency for 200-TW-2 OU will make decisions on the preferred remedial action that will be documented in a ROD. The Hanford Facility RCRA Permit will subsequently be modified by Ecology to incorporate the ROD (and subsequent amendments) by reference, authorizing the RCRA actions at the 200-TW-2 OU.

5.5 POST-ROD ACTIVITIES

After the ROD and modification to the RCRA Hanford Facility Permit have been issued, a remedial design report (RDR) and remedial action work plan (RAWP) will be prepared to detail the scope of the remedial action (which will include RCRA closure and corrective action

requirements). As part of this activity, DQOs will be established and SAPs prepared to direct confirmatory and verification sampling and analysis efforts. Prior to the start of remediation, confirmatory sampling will be performed to ensure that sufficient characterization data are available to confirm that the selected remedy is appropriate for all waste sites within each OU, to collect data necessary for the remedial design, and to support future risk assessments, if needed. Sites that are not appropriate to the remedy will be reassigned to different, more appropriate OUs. Verification sampling will be performed after the remedial action is complete to determine if ROD requirements have been met and if the remedy was effective. Additional guidance for confirmatory and verification sampling is provided in Section 6.2 of the Implementation Plan (DOE-RL 1999).

The RDR/RAWP will include an integrated schedule of remediation activities for the OU and satisfy the requirements for a RPP corrective measures implementation work plan and corrective measures design report. The OU-specific schedules will be developed considering closure/corrective action activities associated with the tank farms so that the OU and tank farm activities can be integrated as appropriate. Following the completion of the remediation effort, closeout activities will be performed as specified in the ROD, RDR/RAWP, and the Permit.

6.0 PROJECT SCHEDULE

The project schedules for activities discussed in this work plan for the 200-TW-1 and 200-TW-2 OUs are shown in Figures 6-1 and 6-2. These schedules will serve as the baseline for the work planning process and will be used to measure the progress of the implementation of this process. The schedules for field activities and the preparation, review, and issuance of the RI report, the FS, and the proposed plan/proposed permit modification are also shown in Figures 6-1 and 6-2. The schedules conclude with the preparation of a ROD.

The portions of the schedule most germane to this work plan and the attached SAP are fiscal years 2000 and 2001. Two Tri-Party Agreement milestones are associated with these operable units: (1) complete Draft A of the 200-TW-1 Work Plan by August 31, 2000, for transmittal to the regulators (M-13-23), and (2) complete Draft A of the 200-TW-2 Work Plan by August 31, 2000, for transmittal to the regulators (M-13-24). This work plan, which covers both OUs, meets both milestones.

The following are proposed project milestone completion dates for key activities at the 200-TW-1 OU:

- Complete fieldwork through drilling and sample collection – *September 30, 2001**
- Submit Draft A RI report for regulator review – *October 30, 2002**
- Submit Draft A FS and Draft A proposed plan for regulator review – *March 31, 2004**.

The following are proposed project milestone completion dates for key activities at the 200-TW-2 OU:

- Complete fieldwork through drilling and sample collection - September 30, 2001*
- Submit Draft A RI report for regulator review – *September 30, 2002**
- Submit Draft A FS and Draft A proposed plan/draft proposed permit modification for regulator review – *March 31, 2004**.

Interim milestones to be designated under the Tri-Party Agreement will be established through negotiations among the Tri-Parties. A Class II change form will be submitted to Ecology and EPA to request the addition of any interim milestones. Any updates to the project schedule or associated milestones will be reflected in the annual work planning process. Currently, only fiscal year 2001 activities are funded.

**Target project milestone*

Figure 6-1. Project Schedule for the 200-TW-1 Operable Unit.

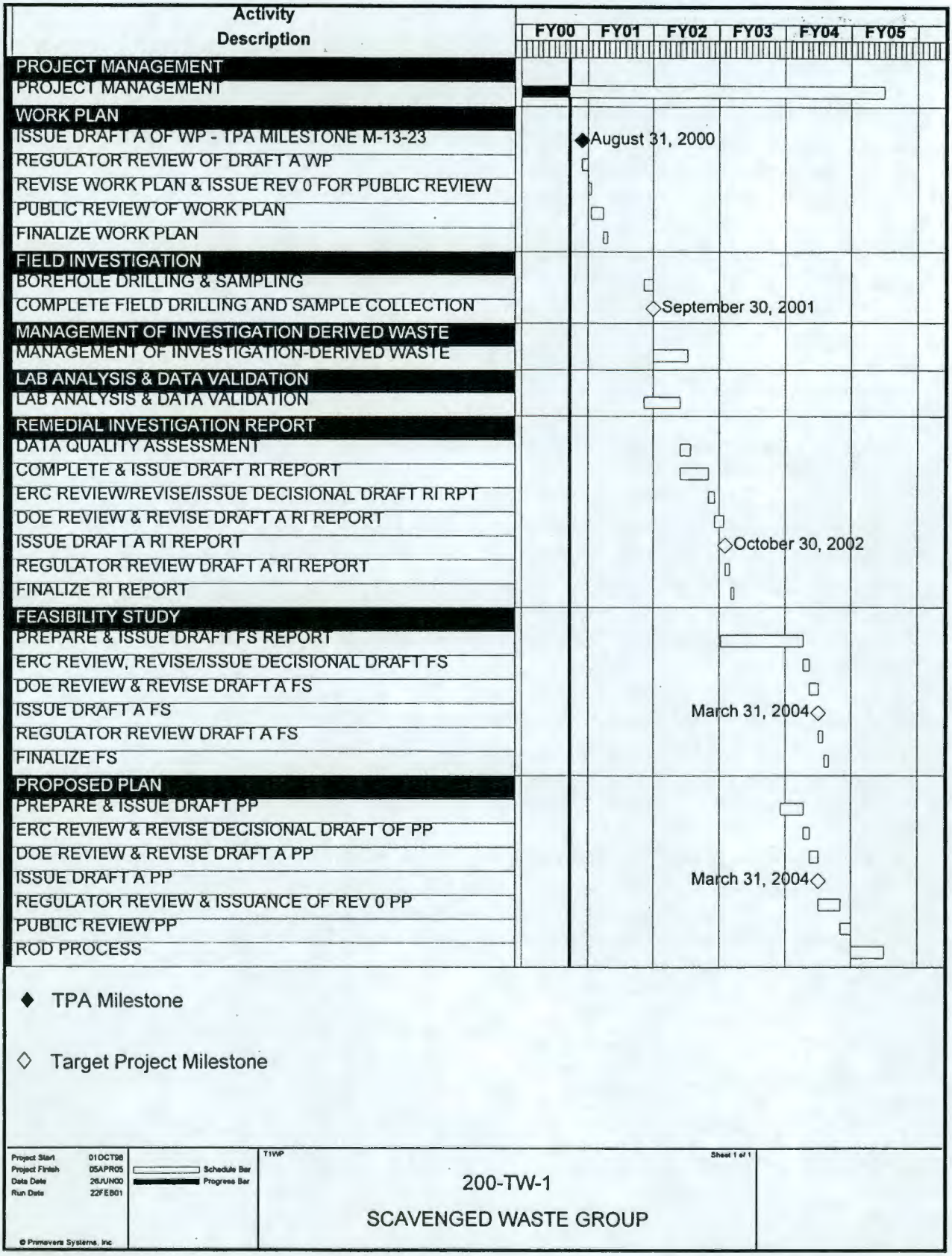
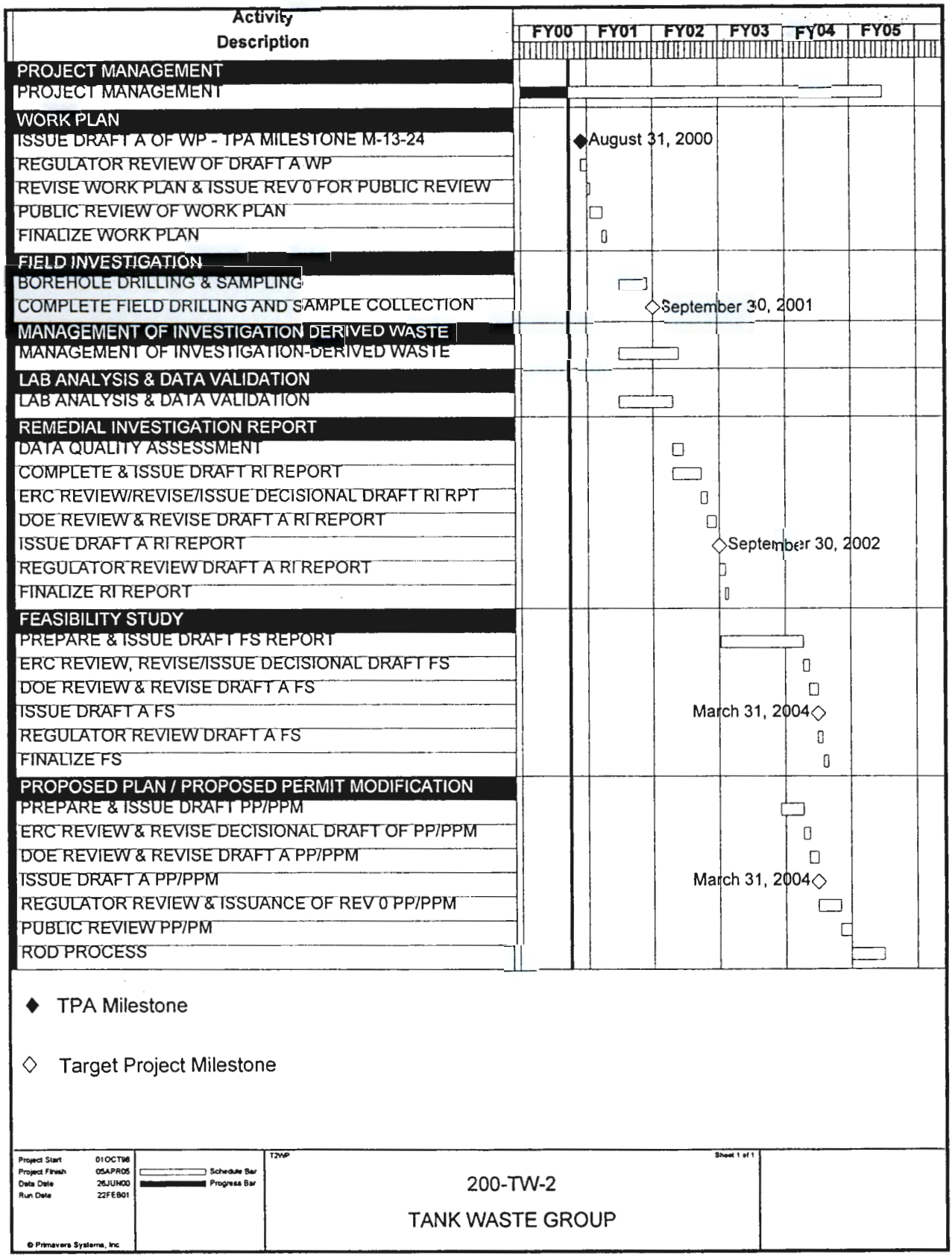


Figure 6-2. Project Schedule for the 200-TW-2 Operable Unit.



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APPENDIX A

SAMPLING AND ANALYSIS PLAN

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ACRONYMNS

ASTM	American Society for Testing and Materials
BHI	Bechtel Hanford, Inc.
bgs	below ground surface
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
COC	contaminant of concern
COPC	contaminant of potential concern
DOE	U.S. Department of Energy
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
ERC	Environmental Restoration Contractor
FS	feasibility study
FSP	field sampling plan
HEIS	Hanford Environmental Information System
OU	operable unit
QAPjP	quality assurance project plan
QC	quality control
RCF	Radiological Counting Facility
RCRA	*Resource Conservation and Recovery Act of 1976*
RCT	radiological control technician
RESRAD	RESidual RADioactivity Dose Model
RI	remedial investigation
S&T	Science and Technology
SAP	sampling and analysis plan
TRU	transuranic
URP	uranium recovery process

APPENDIX A

SAMPLING AND ANALYSIS PLAN

A.1 INTRODUCTION

This sampling and analysis plan (SAP) directs sampling and analysis activities that will be performed to characterize the vadose zone at five waste sites: the 216-B-46 Crib, the 216-T-26 Crib, the 216-B-5 Reverse Well, the 216-B-7A&B Cribs, and the 216-B-38 Trench. These waste sites are part of the 200-TW-1 Scavenged Waste Group and the 200-TW-2 Tank Waste Group Operable Units (OUs) in the 200 Areas of the Hanford Site. The sampling and analyses described in this document will provide soil data to refine the preliminary conceptual contaminant distribution models, support an assessment of risk, and evaluate a range of remedial alternatives for waste sites in these OUs. Characterization activities described in this plan are based on the implementation of the data quality objectives (DQO) process as documented in the *Data Quality Objectives Summary Report for the 200-TW-1 Scavenged Waste Group and 200-TW-2 Tank Waste Group Operable Units* (BHI 2000).

The scope of activities described in this SAP involves sampling and geophysical logging of three deep boreholes to be drilled at three waste sites and geophysical logging of existing boreholes to obtain additional information on the distribution of contamination at four of the waste sites. Boreholes will be drilled to groundwater at the 216-T-26 Crib, the 216-B-7A Crib, and the 216-B-38 Trench. Soil samples will be collected and analyzed for radiological and nonradiological contaminants of concern (COCs) and selected physical properties.

A.1.1 Background

The 64 waste sites associated with the 200-TW-1 and 200-TW-2 OUs primarily received bismuth/phosphate process waste from the T and B Plants. The 200-TW-1 OU waste sites also received Uranium Recovery Process (URP) and ferrocyanide scavenging waste from U Plant. These effluents typically contained higher concentrations of contaminants. The waste was generally neutral to basic in pH and contained a high amount of salts and an extremely low amount of organic constituents. Significant amounts of radionuclides, including uranium, plutonium, and fission products, were released to these waste sites. Contamination has penetrated the vadose zone and reached the aquifer beneath some of the waste sites.

Three of the five representative waste sites within these OU will be characterized to determine the nature and vertical extent of contamination. Knowledge gained from characterizing these sites will be used to refine the preliminary conceptual contaminant distribution models and facilitate the use of the analogous site approach in reaching remedial action decisions for all the waste sites in these OUs. The analogous site approach is described in detail in the *200 Areas Remedial Investigation/Feasibility Study Implementation Plan - Environmental Restoration Program* (Implementation Plan) (DOE-RL 1999).

A.1.2 200-TW-1 and 200-TW-2 Group/Waste Site Locations

The 200-TW-1 and 200-TW-2 OUs are located on the Hanford Site in southeastern Washington State, in the vicinity of the 200 East and 200 West Areas. All waste sites are located within the land-use boundary identified in the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE 1999). Figures 2-1 through 2-4 in the work plan show the specific locations of waste sites in the 200-TW-1 and 200-TW-2 OUs.

A.1.3 Site Description and History

The following sections provide brief descriptions of the five waste sites that will be investigated. More detail is provided in Section 2.2 of the work plan. Section 3.3 of the work plan contains information on the nature and extent of contamination and previous investigations.

A.1.3.1 216-B-46 Crib. The 216-B-46 Crib is one of the BY Cribs, which include waste sites 216-B-43 through 216-B-49 and 216-B-51. The cribs received waste from the ferrocyanide scavenging process and URP. The BY Cribs are located to the north of the BY Tank Farm; they were constructed in 1953 and operated from 1955 until 1958. In 1991, the BY Cribs were characterized during the Phase 1 200-BP-1 OU remedial investigation. Samples were collected and analyzed; the results are reported in the *Phase I Remedial Investigation Report for 200-BP-1 Operable Unit* (DOE-RL 1993, Vol. I and II). Also in 1991, contaminated soil from the surrounding area (UPR-200-E-89) was consolidated on top of the BY Cribs. An additional 0.6 m (2 ft) of clean soil was added to surface stabilize the area.

A.1.3.2 216-T-26 Crib. The 216-T-26 Crib received waste from the ferrocyanide scavenging process and the URP. The crib is located south of 23rd Street and east of Camden Avenue in the 200 West Area. The 216-T-26 Crib was constructed in 1955 and operated from 1955 until 1956. From 1969 to 1979, contaminated Russian thistles caused surface contamination in the area of the crib. In 1975, 15.2 cm (6 in.) of soil was scraped and removed from the waste site. The site was backfilled to its original level with clean soil at that time and was surface stabilized with additional clean fill in 1990.

A.1.3.3 216-B-5 Reverse Well. The 216-B-5 Reverse Well is the deepest Hanford Site reverse well. It received waste from the bismuth/phosphate campaign at B Plant via the 241-B-361 settling tank. The reverse well is located east of Baltimore Avenue and south of the 216-B-9 Crib. The reverse well is approximately 92 m (302 ft) deep and was perforated in both the vadose zone and below the groundwater table, resulting in impacts to the groundwater. The reverse well was constructed in 1944 and operated until 1947 when tank 241-B-361 became full of sludge. In 1994, the surrounding surface contamination area was stabilized with crushed concrete.

A.1.3.4 216-B-7A&B Cribs. The 216-B-7A&B Cribs are two wooden cribs placed side by side and connected by an underground pipe. They received waste from the bismuth-phosphate campaign at B Plant via the 241-B settling tanks. The cribs are located east of Baltimore Avenue and north of the 241-B Tank Farm. The crib structures are 3.7 m by 3.7 m by 1.2 m (12 ft by 12 ft by 4 ft) deep and were originally placed in a 4.3-m (14-ft)-deep excavation. The cribs

received a large volume of liquid effluent and may have impacted the groundwater. The cribs were constructed in 1945 and operated until 1967. In 1994, a surrounding surface contamination area was consolidated and placed on the cribs, increasing the ground surface by approximately 2 m (7 ft). The site was then stabilized with 0.6 m (2 ft) of clean soil.

A.1.3.5 216-B-38 Trench. The 216-B-38 Trench is one of the BX Trenches that received first-cycle waste from the bismuth/phosphate campaign at B Plant from 1953 to 1954. This group of trenches is located north of B Plant and west of the 241-BX Tank Farm. The trenches are approximately 76 m (250 ft) in length by 3 m (10 ft) in width and 3 m (10 ft) deep. The trenches were surface stabilized together in October 1982 with 0.6 m (2 ft) of clean topsoil. The area was then seeded with desert grasses.

A.1.4 Contaminants of Concern

Step 1 of the DQO process identifies the need to develop a list of contaminants of potential concern (COPCs) for the 200-TW-1 and 200-TW-2 OU waste sites. Development of the COPCs is an essential step towards refining the preliminary conceptual contaminant distribution models. From an investigation of historical sources including process documents, logbooks, original plant technical manuals, and interviews of plant operators, a list of potential contaminants was identified. Screening of this list was conducted during the DQO to arrive at a final list of 37 COPCs for the 200-TW-1 OU and 32 COPCs for the 200-TW-2 OU. Development of these lists is described in the 200-TW-1 and 200-TW-2 DQO summary report (BHI 2000) and is summarized in Section 3.5 of the work plan. The COPCs are identified in Tables A-1 and A-2.

If contaminants not identified as COPCs are detected during laboratory analysis, the data will be evaluated against regulatory standards, or risk-based levels if exposure data are available, and existing process knowledge in support of remedial action decision making.

A.1.5 Data Quality Objectives

The U.S. Environmental Protection Agency (EPA) document, *Guidance for the Data Quality Objectives Process* (EPA 1994b), was used to support the development of this SAP. The DQO process is a strategic planning approach that provides a systematic process for defining the criteria that a data collection design should satisfy. Using the DQO process ensures that the type, quantity, and quality of environmental data used in decision making will be appropriate for the intended application.

This section summarizes the key outputs resulting from the implementation of the seven-step DQO process. Additional details are included in the DQO summary report (BHI 2000).

A.1.5.1 Statement of the Problem. The 200-TW-1 and 200-TW-2 OUs consist of 64 waste sites that received mainly process wastes from B, T, and U Plants. Thirty-four of these sites in this group are *Resource Conservation and Recovery Act of 1976* (RCRA) past-practice waste sites and 27 *are Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) past-practice waste sites. Three sites are unplanned release sites. Vadose zone

soils and the aquifer have been impacted by effluent released to the 200-TW-1 and 200-TW-2 waste sites.

The objective of the DQO process for these OUs is to determine the environmental measurements necessary to support the remedial investigation/feasibility study (RI/FS) process and remedial decision making, including refinement of the preliminary conceptual contaminant distribution model. Additionally, the DQO process supports development of this SAP.

Possible alternatives identified in the Implementation Plan (DOE-RL 1999) include the following:

- No action alternative (no institutional controls)
- Engineered multimedia barrier
- Excavation and disposal of waste
- Excavation, ex situ treatment, and geologic disposal of transuranic (TRU) soil
- In situ vitrification of soil
- In situ grouting or stabilization
- Monitored natural attenuation (with institutional controls).

A.1.5.2 Decision Rules. Decision rules are developed from the combined results of DQO Steps 2, 3, and 4. These results include the principal study questions, decision statements, remedial action alternatives, data needs, COC action levels, analytical requirements, and scale of the decision(s). Decision rules are generally structured as "IF...THEN" statements that indicate the action that will be taken when a prescribed condition is met. Decision rules incorporate the parameters of interest (e.g., COCs), the scale of the decision (e.g., location), the preliminary action level (e.g., COC concentration), and the resulting action(s). The 200-TW-1 and 200-TW-2 decision statements are summarized in Table A-3.

A.1.5.3 Error Tolerance and Decision Consequences. The consequence of selecting an inadequate nonstatistical sampling design is not considered severe. Based on Section 6.0 of the DQO summary report (BHI 2000), the sampling design rigor requirements are not significant because of the combination of low severity and accessibility after remedial investigation sampling. If the sampling design is determined to be inadequate, additional sampling can be performed because the sites will be still accessible. Section 5.2 of the work plan summarizes the sampling activities that are planned after the evaluation of initial characterization efforts that are described in this SAP.

A.1.5.4 Sample Design Summary. A nonstatistical sampling design (i.e., professional judgement) was used to select sample locations at the waste sites. This biased (or focused) sampling approach was selected based on process knowledge, expected behavior of COPCs, the observed distribution of contamination, waste site configuration, and the preliminary conceptual contaminant distribution models developed for the waste sites. Using this approach, sample locations are selected that increase the likelihood of encountering the worst-case conditions or maximum concentrations of contaminants.

The total number of samples for the waste sites are selected based on the preliminary conceptual contaminant distribution models and the physical setting of the waste sites. The models suggest that the highest contaminant concentrations should be detected near the bottom of the crib/trench and decrease with depth. Therefore, a greater frequency of sampling is planned in the zone immediately below the release point of the contaminants (i.e., the bottom of the cribs/trenches). Sample frequency will decrease with depth based on the expected distribution of contamination. Additional samples will be collected at the discretion of the site geologist based on the field screening data. All material excavated will be screened as described in Section A.3.2.2. Field screening will be performed to reduce the potential of overlooking zones of significant contamination. The optimal sample design for this initial phase of characterization is presented in Section A.3.

Table A-1. 200-TW-1 Operable Unit Final COC List. (2 Pages)

Final COCs	Rationale for Inclusion
Radiological Constituents	
Americium-241	Known production from fission reaction and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Carbon-14	Known fission product and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Cesium-137	Known fission product (GE 1944 [Sections A, B, and C], GE 1951).
Cobalt-60	Known fission product (GE 1944 [Sections A, B, and C], GE 1951, WHC 1991).
Europium-152	Known fission product (GE 1944 [Sections A, B, and C], FDH 1999).
Europium-154	Known fission product (GE 1944 [Sections A, B, and C], FDH 1999).
Europium-155	Known fission product (GE 1944 [Sections A, B, and C], GE 1951).
Hydrogen-3	Known fission product and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Neptunium-237	Known production from fission reaction and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Nickel-63	Known fission product and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Plutonium-238	Known production from fission reaction (GE 1944, Sections A, B, and C).
Plutonium-239/240	Known production from fission reaction (GE 1944, Sections A, B, and C).
Radium-226	Known production from fission reaction and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Radium-228	Known production from fission reaction and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Total radioactive strontium	Known fission product (GE 1944 [Sections A, B, and C], GE 1951).
Technetium-99	Known fission product (GE 1944 [Sections A, B, and C], WHC 1991).
Thorium-232	Known production from fission reaction (GE 1944 [Sections A, B, and C], FDH 1999).
Uranium-234	Known production from fission reaction (GE 1944, Sections A, B, and C).
Uranium-235	Known production from fission reaction (GE 1944, Sections A, B, and C).
Uranium-238	Known production from fission reaction (GE 1944, Sections A, B, and C).
Nonradiological Constituents – Metals	
Cadmium	Metal used in lead-dipped cladding and cladding waste stream (1952 to 1956) (GE 1944, Section A).
Chromium	Due to sodium/potassium dichromate added during first- and second-cycle decontamination and concentration operations of bismuth-phosphate process (GE 1944 [Section C], WHC 1990).
Chromium (VI)	Due to sodium/potassium dichromate added during first- and second-cycle decontamination and concentration operations of bismuth-phosphate process (GE 1944 [Section C], WHC 1990).
Copper	Metal used in triple-dip process of cladding and cladding waste stream (1944 to 1952) (GE 1944, Section A).
Lead	Metal used in lead-dipped cladding and cladding waste stream (1952 to 1956) (GE 1944, Section A). Lead oxide was added as an oxidizing agent to the first- and second-cycle decontamination operations of bismuth-phosphate process (GE 1944, Section C).
Mercury	Several uses in bismuth-phosphate campaign including addition to cladding and metal waste streams to prevent gaseous generations and misc. Laboratory uses. Listed by the basis of knowledge gained by interviews and via tank farm integration (Agnew et al. 1997).

Table A-1. 200-TW-1 Operable Unit Final COC List. (2 Pages)

Final COCs	Rationale for Inclusion
Nickel	Experimental additions of nickel sulfate added during the bismuth-phosphate process to serve as a scavenging agent. Listed as a result of tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991) and extensive use (1954 to 1958) as nickel ferro/ferric cyanide during scavenging and recovery processes (GE 1951).
Silver	Several uses in bismuth-phosphate campaign including filtering of gases generated (1950s) and miscellaneous laboratory uses. Listed by the basis of knowledge gained by interviews.
Nonradiological Constituents – General Inorganics	
Ammonia/ammonium	Several compounds contained ammonium. The most widely used included ammonium silica fluoride, which was used as a cleaning and decontamination compound based on the ability to dissolve metals and fission products (GE 1944 [Section C], GE 1951, HEW 1945).
Chloride	Several compounds contained chloride. The most widely used included ferrous chloride, which was used as a carrier and potassium/sodium chloride used as salting agents during the bismuth-phosphate process (GE 1944 [Section C], GE 1951, HEW 1945).
Cyanide	Extensive use (1954 to 1958) as nickel ferro/ferric cyanide during scavenging and recovery processes. Listed as a result of tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991, GE 1951).
Fluoride	Several compounds contained fluoride. The most widely used included lanthanum fluoride (which was used during the concentration operations of the bismuth-phosphate process) and ammonium silica fluoride (which was used as a cleaning and decontamination compound based on ability to dissolve metals and fission products) (GE 1944 [Section C], GE 1951, HEW 1945).
Nitrate/nitrite	Several compounds contained nitrates/nitrites, the most widely used included sodium nitrite (a salting agent during the cladding removal), nitric acid (used throughout the bismuth-phosphate process and URP), and bismuth subnitrate (used to create the bismuth-phosphate/plutonium solid during the first and second decontamination cycles) (GE 1944 [Section C], GE 1951, HEW 1945).
Phosphate	Several compounds contained phosphate. The most widely used included phosphoric acid, which was used throughout bismuth-phosphate process (GE 1944 [Section C], HEW 1945).
Sulfate	Several compounds contained sulfate. The most widely used included sulfuric acid, which was used in the dissolving of the fuel rod during the bismuth-phosphate process (GE 1944 [Section C], GE 1951, HEW 1945). Many other sulfate complexes were used as carriers for various metals.
Semi-Volatile Organics	
AMSCO[a]	Extensive use (1953 to 1957) in solvent extraction operation as the dilutant for TBP in the URP (GE 1951).
Dodecane[a]	Extensive use (1953 to 1957) in solvent extraction operation as the dilutant for TBP in the URP (GE 1951).
Normal paraffins[a]	Extensive use (1953 to 1957) in solvent extraction operation as the dilutant for TBP in URPs (GE 1951).
Tributyl phosphate and derivatives (mono, bi)	Extensive use (1953 to 1957) in solvent extraction operation as the bismuth-phosphate complexent in the URPs (GE 1951).

[a]Analyzed as kerosene total petroleum hydrocarbons.
TBP = tributyl phosphate

Table A-2. 200-TW-2 Operable Unit Final COC List. (2 Pages)

Final COCs	Rationale for Inclusion
Radiological Constituents	
Americium-241	Known production from fission reaction and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Carbon-14	Known fission product and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Cesium-137	Known fission product (GE 1944 [Sections A, B, and C], GE 1951).
Cobalt-60	Known fission product (GE 1944 [Sections A, B, and C], GE 1951, WHC 1991).
Europium-152	Known fission product (GE 1944 [Sections A, B, and C], FDH 1999).
Europium-154	Known fission product (GE 1944 [Sections A, B, and C], FDH 1999).
Europium-155	Known fission product (GE 1944 [Sections A, B, and C], GE 1951)
Hydrogen-3	Known fission product and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Neptunium-237	Known production from fission reaction and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Nickel-63	Known fission product and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Plutonium-238	Known production from fission reaction (GE 1944, Sections A, B, and C).
Plutonium-239/240	Known production from fission reaction (GE 1944, Sections A, B, and C).
Radium-226	Known production from fission reaction and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Radium-228	Known production from fission reaction and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Total radioactive strontium	Known fission product (GE 1944 [Sections A, B, and C], GE 1951).
Technetium-99	Known fission product (GE 1944 [Sections A, B, and C], WHC 1991).
Thorium-232	Known production from fission reaction (GE 1944 [Sections A, B, and C], FDH 1999).
Uranium-234	Known production from fission reaction fission product (GE 1944, Sections A, B, and C).
Uranium-235	Known production from fission reaction (GE 1944, Sections A, B, and C).
Uranium-238	Known production from fission reaction (GE 1944, Sections A, B, and C).
Nonradiological Constituents – Metals	
Cadmium	Metal used in lead-dipped cladding and cladding waste stream (1952 to 1956) (GE 1944, Section A).
Chromium	Due to sodium/potassium dichromate added during first- and second-cycle decontamination and concentration operations of bismuth-phosphate process (GE 1944 [Section C], WHC 1990).
Chromium (VI)	Due to sodium/potassium dichromate added during first- and second-cycle decontamination and concentration operations of bismuth-phosphate process (GE 1944 [Section C], WHC 1990).
Copper	Metal used in triple-dip process of cladding and cladding waste stream (1944 to 1952) (GE 1944, Section A).
Lead	Metal used in lead-dipped cladding and cladding waste stream (1952 to 1956) (GE 1944, Section A). Lead oxide was added as an oxidizing agent to the first- and second-cycle decontamination operations of bismuth-phosphate process (GE 1944, Section C).
Mercury	Several uses in bismuth-phosphate campaign including addition to cladding and metal waste streams to prevent gaseous generations and miscellaneous laboratory uses. Listed by the basis of knowledge gained by interviews and via tank farm integration (Agnew et al. 1997).

Table A-2. 200-TW-2 Operable Unit Final COC List. (2 Pages)

Final COCs	Rationale for Inclusion
Nickel	Experimental additions of nickel sulfate added during the bismuth-phosphate process to serve as a scavenging agent. Listed as a result of tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991) and extensive use (1954 to 1958) as nickel ferro/ferric cyanide during scavenging and recovery processes (GE 1951)
Silver	Several uses in bismuth-phosphate campaign including filtering of gases generated (1950s) and miscellaneous laboratory uses. Listed by the basis of knowledge gained by interviews.
Nonradiological Constituents – General Inorganics	
Ammonia/Ammonium	Several compounds contained ammonium. The most widely used included ammonium silica fluoride, which was used as a cleaning and decontamination compound based on its ability to dissolve metals and fission products (GE 1944 [Section C], GE 1951, HEW 1945).
Chloride	Several compounds contained chloride. The most widely used included ferrous chloride, which was used as a carrier and potassium/sodium chloride used as salting agents during the bismuth-phosphate process (GE 1944 [Section C], GE 1951, and HEW 1945).
Fluoride	Several compounds contained fluoride. The most widely used included lanthanum fluoride, which was used during the concentration operations of the bismuth-phosphate process, and ammonium silica fluoride, which was used as a cleaning and decontamination compound based on its ability to dissolve metals and fission products (GE 1944 [Section C], GE 1951, HEW 1945).
Nitrate/nitrite	Several compounds contained nitrates/nitrites. The most widely used included sodium nitrite (a salting agent during the cladding removal), nitric acid (used throughout the bismuth-phosphate and uranium-recovery processes), and bismuth subnitrate (used to create the bismuth- phosphate/plutonium solid during the first and second decontamination cycles (GE 1944 [Section C], GE 1951, HEW 1945).
Phosphate	Several compounds contained phosphate. The most widely used included phosphoric acid, which was used throughout bismuth-phosphate process (GE 1944 [Section C], HEW 1945).
Sulfate	Several compounds contained sulfate. The most widely used included sulfuric acid, which was used in the dissolving of the fuel rod during the bismuth-phosphate process (GE 1944 [Section C], GE 1951, HEW 1945). Many other sulfate complexes were used as carriers for various metals.

Table A-3. Decision Rules.

DR #	Decision Rule
1	If the detected soil sampling results in the 200-TW-1 and 200-TW-2 OU representative waste site vadose soils exceed the TRU definition of 100 nCi/g, then analyze the nonradiological constituents and evaluate the need for special remedial action alternatives in a FS. If the detected soil sampling results in the 200-TW-1 and 200-TW-2 OU representative waste site vadose soils do not exceed the TRU definition of 100 nCi/g, then evaluate the other radiological constituents and the nonradiological constituents in accordance with DR #2.
2	If the analytical results of the soils samples collected from the 200-TW-1 and 200-TW-2 OU waste sites meet all of the following conditions: • The RESRAD analysis of maximum detected soil sampling results for the radiological COCs in the 200-TW-1 and 200-TW-2 OU representative waste site vadose soils do not exceed the annual exposure limits for human health protection. • The fate and transport analysis (TBD) of the maximum detected soil sampling results for the radiological COCs in the 200-TW-1 and 200-TW-2 OU representative waste site vadose soils do not exceed the annual exposure limits for protection of groundwater. • The analytical results of the 200-TW-1 and 200-TW-2 OU representative waste sites indicate that detected values do not exceed the respective nonradiological COC preliminary action levels for direct exposure. • The analytical results of the 200-TW-1 and 200-TW-2 OU representative waste site vadose soils indicate that the detected values do not exceed the respective nonradiological COC preliminary action levels for protection of groundwater. Then evaluate for site closure with no remedial action. If any of these conditions are not met, then evaluate the need for conventional remedial action alternatives within an FS, or evaluate a streamlined approach to site closure to be applied administratively via an existing record of decision.
3	If the detected values indicate that the contamination distribution and physical characteristics in the 200-TW-1 and 200-TW-2 OU waste sites do not differ significantly from the preliminary conceptual contaminant distribution model, then the preliminary conceptual contaminant distribution model will not be revised prior to use for remedial decision making or remedial action planning. If the detected values indicate that the contamination distribution and physical properties in the 200-TW-1 and 200-TW-2 OU waste sites differ significantly from the preliminary conceptual contaminant distribution model, then the preliminary conceptual contaminant distribution model will be revised prior to use for remedial decision making or remedial action planning.

[a]The use of the term "remedial action" is used collectively to refer to one of the alternatives described in the project objectives discussion. The selection of the appropriate alternative action is beyond the scope of this DQO summary report.
DR = decision rule
TBD = to be determined

A.2 QUALITY ASSURANCE PROJECT PLAN

The quality assurance project plan (QAPjP) establishes the quality requirements for environmental data collection, including sampling, field measurements, and laboratory analysis. The overall QAPjP for Environmental Restoration waste sites in the 200 Areas is included in Appendix A of the Implementation Plan (DOE-RL 1999). The QAPjP complies with the requirements of the following:

- U.S. Department of Energy (DOE) Order 5700.6c, *Quality Assurance*
- *Code of Federal Regulations* (CFR), 40 CFR 830.120, "Quality Assurance Requirements"
- *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations* (EPA 1994a)
- *Hanford Analytical Services Quality Assurance Requirements Documents* (DOE-RL 1996a).

The Implementation Plan provides the general framework of technical and administrative requirements that apply to OUs in the 200 Areas.

To meet the site-specific needs for the 200-TW-1 and 200-TW-2 OUs, this QAPjP identifies supplemental requirements developed during the DQO process and described in the group-specific SAP. These requirements are listed below:

- **Analytical Performance.** Requirements for detection limits, precision, and accuracy are presented in Table A-4. The analytical methods are also shown in this table.
- **Field Quality Control.** The frequency and type of quality control (QC) samples to be collected are addressed in Section A.2.1.
- **Sample Preservation, Containers, and Holding Time.** The requirements for the specific test/laboratory methods are addressed in Section A.2.3 and in Table A-5.
- **Onsite Measurements Quality Control.** The specific types of QC samples for onsite measurements and the frequency of collection are addressed in Section A.2.4.
- **Data Validation and Usability.** Specific validation requirements, including the frequency and level of validation, are addressed in Section A.2.6.

The following sections describe the supplemental waste group quality requirements and the procedural controls applicable to this investigation. The 200 Areas QAPjP (Appendix A of the Implementation Plan [DOE-RL 1999]) and this section of the SAP will serve as the QAPjP for the 200-TW-1 and 200-TW-2 RI.

A.2.1 Field Quality Control

Field QC samples shall be collected to evaluate the potential for cross-contamination and laboratory performance. Field QC for sampling in the 200-TW-1 and 200-TW-2 OUs will require the collection of co-located duplicate, field split, and equipment rinsate blank samples. The QC samples are described in this section with the required frequency of collection.

QC samples will not be collected from zones within the boreholes that are expected to contain TRU-contaminated soils, because of the extreme cost and handling requirements associated with TRU materials.

A.2.1.1 Co-Located Duplicates. Co-located duplicates are independent samples collected as close as possible to the same point in space and time, taken from the same source, stored in separate containers, and analyzed independently. These samples are useful in documenting homogeneity in the soil. It is important that these samples are not homogenized together.

A minimum of 5% of the total collected soil samples will be duplicated (i.e., 1 field duplicate will be collected for every 20 samples). At least one co-located duplicate will be collected from each borehole. The duplicates should generally be collected from an area that is expected to have some contamination, so that valid comparisons between the samples can be made (i.e., at least some of the COCs will be above detection limit). When sampling with a split spoon, the duplicate sample will probably be from a separate split spoon either above or below the main sample because of volume constraints.

A.2.1.2 Field Splits. Field split samples will be collected from each representative site to be sampled in the RI (216-T-26, 216-B-7A/B, and 216-B-38). The split samples shall each be retrieved from the same sample interval using the same equipment (collected from one split spoon) and sampling technique; sampling limitations involving split spoons as discussed in Section A.2.1.1 also apply to field splits. Samples shall be homogenized, split into two separate aliquots in the field, and sent to two independent laboratories. The splits will be used to verify the performance of the primary laboratory.

The split samples will be obtained from sample media suitable for analysis in an offsite laboratory and shall be analyzed for all of the COCs listed in Table A-4.

A.2.1.3 Equipment Rinsate Blanks. Equipment rinsate blanks shall be collected at the same frequency as co-located duplicate samples, where applicable, and are used to verify the adequacy of sampling equipment decontamination procedures. The field geologist may request that additional equipment blanks be taken. Equipment blanks shall consist of pure deionized water washed through decontaminated sampling equipment and placed in containers identical to those used for actual field samples.

Equipment rinsate blanks shall be analyzed for the following:

- Gross alpha
- Gross beta

- Metals (excluding hexavalent chromium and mercury)
- Anions (except cyanide)
- Volatile organic analytes of interest.

These analytes are considered to be the best indicators of decontamination effectiveness.

A.2.1.4 Prevention of Cross-Contamination. Special care should be taken to prevent cross-contamination of soil samples. Particular care will be exercised to avoid the following common ways in which cross-contamination or background contamination may compromise the samples:

- Improperly storing or transporting sampling equipment and sample containers
- Contaminating the equipment or sample bottles by setting them on or near potential contamination sources, such as uncovered ground
- Handling bottles or equipment with dirty hands
- Improperly decontaminating equipment before sampling or between sampling events.

A.2.2 Quality Objectives and Criteria for Measurement Data

Quality objectives and criteria for soil measurement data are presented in Table A-4 for chemical and radiological analytes, as well as physical properties of interest. Analysis of soil physical properties will be performed according to American Society for Testing and Materials (ASTM) procedures, if applicable.

A.2.3 Sample Preservation, Containers, and Holding Times

Soil sample preservation, containers, and holding times for chemical and radiological analytes of interest and physical property test are presented in Table A-5. Final sample collection requirements will be identified on the Sampling Authorization Form.

A.2.4 Onsite Measurements Quality Control

The collection of QC samples for onsite measurements is not applicable to field-screening techniques described in this plan. Field-screening instrumentation will be calibrated and controlled according to the procedures identified in Section A.2.7.

A.2.5 Data Management

Data resulting from the implementation of this QAPjP will be managed and stored by the Environmental Restoration Contractor (ERC) organization responsible for sampling and characterization, in accordance with BHI-EE-01, *Environmental Investigations Procedures*, Section 2.0, "Sample Management." At the direction of the task lead, all analytical data packages will be subject to final technical review by qualified personnel before their submittal to

regulatory agencies or inclusion in reports. Electronic data access, when appropriate, will be via a database (e.g., Hanford Environmental Information System [HEIS] or a project-specific database). Where electronic data are not available, hard copies will be provided in accordance with Section 9.6 of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1998).

A.2.6 Validation and Verification Requirement

Validation will be performed on completed data packages by qualified Bechtel Hanford, Inc (BHI) Sample Management personnel or by a qualified independent contractor. Validation will consist of verifying required deliverables, requested versus reported analyses, and transcription errors. Validation will also include the evaluation and qualification of results based on holding time, method blanks, matrix spikes, laboratory control samples, laboratory duplicates, and chemical and tracer recoveries, as appropriate to the methods used. No other validation or calculation checks will be performed. At least 5% of all data will be validated.

Assuming that about 50 samples will be collected during the 200-TW-1 and 200-TW-2 OU representative site investigations (including full QC sets, but exclusive of discretionary samples; see Tables A-7 through A-9), approximately 3 to 8 sample delivery groups will be submitted to the laboratory containing between 6 and 18 samples in each sample delivery groups. At least one data validation package will be generated for each OU. Validation requirements identified in this section are consistent with Level C validation, as defined in data validation procedures (WHC 1993a, 1993b). No validation for physical property data will be performed.

A.2.7 Technical Procedures and specifications

Soil sampling and onsite environmental measurements will be performed according to approved procedures. Sampling and field measurements will be conducted according to BHI-EE-01, *Environmental Investigations Procedures*; BHI-EE-05, *Field Screening Procedures*; and other approved procedures listed below. Individual procedures that may be used during performance of this SAP include the following:

- BHI-EE-01, *Environmental Investigations Procedures*

  Section 1.0, General Information

  - Procedure 1.5, "Field Logbooks"
  - Procedure 1.6, "Survey Requirements and Techniques"

  Section 2.0, Sample Management

  - Procedure 2.0, "Sample Event Coordination"
  - Procedure 2.1, "Sampling Documentation Processing"

Section 3.0, General Sampling

- Procedure 3.0, "Chain of Custody"
- Procedure 3.1, "Sample Packaging and Shipping"
- Procedure 3.2, "Field Decontamination of Sampling Equipment"

Section 4.0, Soil, Groundwater, and Biotic Sampling

- Procedure 4.0, "Soil and Sediment Sampling"
- Procedure 4.2, "Sample Storage and Shipping Facility"

Section 6.0, Drilling

- Procedure 6.2, "Field Cleaning and/or Decontamination of GeoProbe and Drilling Equipment"

Section 7.0, Geologic and Hydrologic Data Collection

- Procedure 7.0, "Geologic Logging"
- Procedure 7.2, "Geophysical Survey Work"

- BHI-EE-02, *Environmental Requirements*
  - Procedure 14.0, "Drilling, Maintaining, Remediating, and Decommissioning Resource Protection Wells, Geoprobe and Geotechnical Soil Borings"
- BHI-EE-05, *Field Screening Procedures*
  - Procedure 1.0, "Routine Field Screening"
  - Procedure 2.5, "Operation of Mobile Surface Contaminant Monitor II"
  - Procedure 2.22, "Operation of Global Positioning Environmental Radiological Surveyor (GPERS-II)"
- BHI-EE-10, *Waste Management Plan, Part II*
  - Section 9.0, "Control of CERCLA and Other Past-Practice Investigation-Derived Waste"

Work shall also be performed in accordance with the following manuals:

- BHI-EE-02, *Environmental Requirements*, Section 11.0, "Solid Waste System Operations"
- BHI-QA-01, *ERC Quality Program*
- BHI-QA-03, *ERC Quality Assurance Program Plans*
  - Plan 5.1, "Field Sampling Quality Assurance Program Plan"

  - Plan 5.2, "Onsite Measurements Quality Assurance Program Plan"
  - Plan 5.3, "Environmental Radiological Measurements Quality Assurance"

- BHI-MA-02, *ERC Project Procedures*
- BHI-SH-01, *ERC Safety and Health Program*
- BHI-SH-02, *Safety and Health Procedures*, Volumes 1, 3, and 4
- BHI-SH-05, *Industrial Hygiene Work Instructions*
- BHI-EE-10, *Waste Management Plan*
- BHI-RC-04, *Radiological Control Work Instructions*
- *Hanford Site Radiation Control Manual* (DOE-RL 1996b)
- Specification for environmental drilling services specific to 200-TW-1 and 200-TW-2
- *Sampling Services Procedures Manual*, ES-SSPM-001, Rev. 0, Procedure 2-5, "Laboratory Cleaning of Sampling Equipment," Waste Management Northwest (WMNW 1998).

A.2.7.1 Sample Location. Sample locations (e.g., geophysical surveys and boreholes) will be staked and labeled before starting the activity. Locations will be staked by the technical lead or field team leader assigned by the project manager. After the locations have been staked, minor adjustments to the location may be made to mitigate unsafe conditions, avoid structural interferences, or bypass utilities. Locations will be identified during or after sampling following BHI-EE-01, Procedure 1.6, "Survey Requirements and Techniques." Changes in sample locations that do not impact the DQOs will require approval of the project manager. However, changes to sample locations that result in impacts to the DQOs will require EPA (for 216-T-26) or Washington State Department of Ecology (for 216-B-7A and 216-B-38) concurrence.

A.2.7.2 Sample Identification. The ERC Sample and Data Tracking database will be used to track the samples through the collection and laboratory analysis process. The HEIS database is the repository for the laboratory analytical results. The HEIS sample numbers will be issued to the sampling organization for this project in accordance with BHI-EE-01, Procedure 2.0, "Sample Event Coordination." Each chemical/radiological and physical properties sample will be identified and labeled with a unique HEIS sample number. The sample location, depth, and corresponding HEIS numbers will be documented in the sampler's field logbook.

Each sample container will be labeled with the following information using a waterproof marker on firmly affixed, water-resistant labels:

- HEIS number
- Sample collection date/time
- Name/initials of person collecting the sample
- Analysis required

- Preservation method, if applicable.

A.2.7.3 Field Sampling Log. All information pertinent to field sampling and analysis will be recorded in bound logbooks in accordance with BHI-EE-01, Procedure 1.5, "Field Logbooks." The sampling team will be responsible for recording all relevant sampling information including, but not limited to, the information listed in Appendix A of Procedure 1.5. Entries made in the logbook will be dated and signed by the individual who made the entry.

A.2.7.4 Sample Custody. A chain-of-custody record will be initiated in the field at the time of sampling and will accompany each set of samples (cooler) shipped to any laboratory in accordance with BHI-EE-01, Procedure 3.0, "Chain of Custody." The analyses requested for each sample will be indicated on the accompanying chain-of-custody form. Chain-of-custody procedures will be followed throughout sample collection, transfer, analysis, and disposal to ensure that sample integrity is maintained. Each time responsibility for custody of the sample changes, the new and previous custodians will sign the record and note the date and time. The sampler will make a copy of the signed record before sample shipment and transmit it to ERC Sample Management within 24 hours of shipping, as detailed in BHI-EE-01, Procedure 2.1, "Sampling Documentation Processing."

A custody seal (i.e., evidence tape) shall be affixed to the lid of each sample jar. The container seal will be inscribed with the sampler's initials and the date sealed. For any sample jars collected inside the glovebag or glovebox and "bagged out," the evidence tape may be affixed to the seal of the bag to demonstrate that tampering has not occurred. This will eliminate problems associated with contaminated soils adhering to the custody tape while inside the glovebox.

A.2.7.5 Sample Containers and Preservatives. Level I EPA pre-cleaned sample containers will be used for soil samples collected for chemical and radiological analysis. Container sizes may vary depending on laboratory-specific volumes needed to meet analytical detection limits. If, however, the dose rate on the outside of a sample jar or the curie content exceeds levels acceptable by an offsite laboratory, the sampling lead and task lead can send smaller volumes to the laboratory after consultation with ERC Sample Management to determine acceptable volumes. Preliminary container types and volumes are identified in Table A-5. Final types and volumes will be provided in the Sample Authorization Form.

A.2.7.6 Sample Shipping. The outside of each sample jar will be surveyed by the radiological control technician (RCT) to verify that the container is free of smearable surface contamination. The RCT will also measure the radiological activity on the outside of the sample container (through the container) and will mark the container with the highest contact radiological reading in either dpm or mrem/hr, as applicable. Unless pre-qualified, all samples will have total activity analysis performed by the Radiological Counting Facility (RCF), 222-S Laboratory, or other suitable onsite laboratory, before shipment. This information, along with other data that may pre-qualify the samples, will be used to select proper packaging, marking, labeling, and shipping paperwork in accordance with U.S. Department of Transportation regulations (49 CFR) and to verify that the sample can be received by the offsite analytical laboratory in accordance with the laboratory's acceptance criteria. The sampler will send copies of the shipping documentation to

ERC Sample Management within 24 hours of shipping, as detailed in BHI-EE-01, Procedure 2.1, "Sampling Documentation Processing."

As a general rule, samples with activities <1 mR/hr will be shipped to an offsite laboratory. Samples with activities between 1 mR/hr and 10 mR/hr may be shipped to an offsite laboratory; samples with activities in this range will be evaluated on a case-by-case basis by ERC Sample Management. Samples with activities >10 mR/hr will be sent to an onsite laboratory arranged by Sample Management. Potential impacts of onsite laboratory measurements are discussed in footnote a of Table A-4.

Table A-4. Analytical Performance Requirements – Shallow and Deep Zone Soils. (3 Pages)

COCs	CAS #	Preliminary Action Level[a]			Name/Analytical Technology[d]	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
		RR[b] (pCi/g)	C/I[b] (pCi/g)	GW[b,c] Protection (pCi/g)		Water[e] Low Activity (pCi/L)	Water[e] High Activity pCi/L)	Soil-Other Low Activity (pCi/g)	Soil-Other High Activity (pCi/g)				
Americium-241	14596-10-2	31	210	TBD	Americium isotopic – AEA	1	400	1	4,000	+-20%	70-130%	+-35%	70-130%
Carbon-14	14762-75-5	5.2[f]	33,100	TBD	Carbon-14 - liquid scintillation	200	N/A	50	N/A	+-20%	70-130%	+-35%	70-130%
Cesium-137	10045-97-3	6.2	25	TBD	GEA	15	200	0.1	2,000	+-20%	70-130%	+-35%	70-130%
Cobalt-60	10198-40-0	1.4	5.2	TBD	GEA	25	200	0.05	2,000	+-20%	70-130%	+-35%	70-130%
Europium-152	14683-23-9	3.3	12	TBD	GEA	50	200	0.1	2,000	+-20%	70-130%	+-35%	70-130%
Europium-154	15585-10-1	3	11	TBD	GEA	50	200	0.1	2,000	+-20%	70-130%	+-35%	70-130%
Europium-155	14391-16-3	125	449	TBD	GEA	50	200	0.1	2,000	+-20%	70-130%	+-35%	70-130%
Hydrogen-3	10028-17-8	359[f]	14,200	TBD	Tritium – liquid scintillation	400	400	400	400	+-20%	70-130%	+-35%	70-130%
Neptunium-237	13994-20-2	2.5	62.2	TBD	Neptunium-237 - AEA	1	N/A	1	8,000	+-20%	70-130%	+-35%	70-130%
Nickel-63	13981-37-8	4,026	3,008,000	TBD	Nickel-63 - liquid scintillation	15	N/A	30	N/A	+-20%	70-130%	+-35%	70-130%
Plutonium-238	13981-16-3	37	483	TBD	Plutonium isotopic – AEA	1	130	1	1,300	+-20%	70-130%	+-35%	70-130%
Plutonium-239/240	Pu-239/240	34	243	TBD	Plutonium isotopic – AEA	1	130	1	1,300	+-20%	70-130%	+-35%	70-130%
Radium-226	13982-63-3	1.1	7.4	TBD	GEA	50	N/A	0.1	2,000	+-20%	70-130%	+-35%	70-130%
Radium-228	15262-20-1	1.7	8.5	TBD	GEA	50	N/A	0.2	2,000	+-20%	70-130%	+-35%	70-130%
Strontium-90	Rad-Sr	4.5	2,500	TBD	Total radioactive strontium - GPC	2	80	1	800	+-20%	70-130%	+-35%	70-130%
Technetium-99	14133-76-7	5.7[f]	410,000	TBD	Technetium-99 - liquid scintillation	15	400	15	4,000	+-20%	70-130%	+-35%	70-130%
Thorium-232	Th-232	1	5.1	TBD	Thorium isotopic - AEA (pCi) ICPMS (mg)	1	0.002 mg/L	1	0.02 mg/kg	+-20%	70-130%	+-35%	70-130%
Uranium-234	13966-29-5	160	1200	TBD	Uranium isotopic - AEA (pCi) ICPMS (mg)	1	0.002 mg/L	1	0.02 mg/kg	+-20%	70-130%	+-35%	70-130%
Uranium-235	15117-96-1	26	100	TBD	Uranium isotopic - AEA (pCi) ICPMS (mg)	1	0.002 mg/L	1	0.02 mg/kg	+-20%	70-130%	+-35%	70-130%
Uranium-238	U-238	85	420	TBD	Uranium isotopic - AEA (pCi) ICPMS (mg)	1	0.002 mg/L	1	0.02 mg/kg	+-20%	70-130%	+-35%	70-130%

Table A-4. Analytical Performance Requirements – Shallow and Deep Zone Soils. (3 Pages)

COCs	CAS #	Preliminary Action Level[a]			Name/Analytical Technology[d]	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
		Method B[g] (mg/kg)	Method C[h] (mg/kg)	GW Protection[l] mg/kg		Water[e] Low Conc. (mg/L)	Water[e] High Conc. (mg/L)	Soil-Other Low Conc. (mg/kg)	Soil-Other High Conc. (mg/kg)				
Metals													
Cadmium	7440-43-9	80	3,500	0.5[i]	Metals - 6010 - ICP	0.005	0.01	0.5	1	j	j	j	j
Cadmium	7440-43-9	80	3,500	0.5[i]	Metals - 6010 – ICP (trace)	0.005	N/A	0.5	N/A	j	j	j	j
Chromium (total)	7440-47-3	80,000[l]	Unlimited[l]	10[j]	Metals - 6010 - ICP	0.01	0.01	1	2	j	j	j	j
Chromium (total)	7440-47-3	80,000[l]	Unlimited[l]	10[j]	Metals - 6010 – ICP (trace)	0.01	N/A	1	N/A	j	j	j	j
Chromium VI	18540-29-9	400	17,500	8	Chromium (hex) - 7196 - colorimetric	0.01	4	0.5	200	j	j	j	j
Copper	7440-50-8	2,960	130,000	59.2	Metals - 6010 - ICP	0.025	0.025	2.5	2.5	j	j	j	j
Lead	7439-92-1	353[m]	1,000[n]	1.5[o]	Metals - 6010 - ICP	0.1	0.2	10	20	j	j	j	j
Lead	7439-92-1	353[m]	1,000[n]	1.5[o]	Metals - 6010 - ICP(trace)	0.01	N/A	1	N/A	j	j	j	j
Mercury	7439-97-6	24	1,050	0.2[i]	Mercury - 7470 - CVAA	0.0005	0.005	N/A	N/A	j	j	j	j
Mercury	7439-97-6	24	1,050	0.2[i]	Mercury - 7471 - CVAA	N/A	N/A	0.2	0.2	j	j	j	j
Nickel	7440-02-0	1,600[o]	70,000[o]	32	Metals - 6010 - ICP	0.04	0.04	4	4	j	j	j	j
Silver	7440-22-4	400	17,500	8	Metals - 6010 - ICP	0.02	0.02	2	2	j	j	j	j
Silver	7440-22-4	400	17,500	8	Metals - 6010 - ICP(trace)	0.005	N/A	0.5	N/A	j	j	j	j
Uranium (total)	7440-61-1	240[o]	10,500[o]	2[p]	Uranium total - kinetic phosphorescence analysis	0.0001	0.02	1	0.2	+-20%	70-130%	+-35%	70-130%
Inorganics													
Ammonia/ ammonium	7664-41-7	Unlimited	Unlimited	27,200	Ammonia - 350.1[q]	0.05	800	0.5	8,000	j	j	j	j
Chloride	16887-00-6	25,000[t]	25,000[t]	25,000[t]	Anions - 300.0 - IC	0.2	5	2	5	j	j	j	j
Cyanide	57-12-5	1,600	70,000	20[j]	Total cyanide - 9010 - colorimetric	0.005	0.005	0.5	0.5	j	j	j	j
Fluoride	16984-48-8	4,800	210,000	96	Anions - 300.0 - IC	0.5	5	5	5	j	j	j	j
Nitrate	14797-55-8	128,000	Unlimited	4,400	IC 353.1[q] and EPA 300.0	0.25	10	2.5	40	j	j	j	j
Nitrite	14797-65-0	8,000	350,000	160	IC 353.1[r] and EPA 300.0	0.25	15	2.5	20	j	j	j	j
Phosphate	14265-44-2	N/A	N/A	None	Anions - 300.0 – IC	0.5	15	5	40	j	j	j	j
Sulfate	14808-79-8	25,000[t]	25,000[t]	25,000[t]	Anions - 300.0 – IC	0.5	15	5	40	j	j	j	j

Table A-4. Analytical Performance Requirements – Shallow and Deep Zone Soils. (3 Pages)

COCs	CAS #	Preliminary Action Level[a]			Name/Analytical Technology[d]	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
		Method B[g] (mg/kg)	Method C[h] (mg/kg)	GW Protection[i] mg/kg		Water[e] Low Conc. (mg/L)	Water[e] High Conc. (mg/L)	Soil-Other Low Conc. (mg/kg)	Soil-Other High Conc. (mg/kg)				
Organics													
Kerosene (normal paraffin hydrocarbons)	8008-20-6	200[n]	200[n]	200	Non-halogenated VOA - 8015M - GC modified for hydrocarbons	0.5	0.5	5	5	[k]	[k]	[k]	[k]
Tributyl phosphate	126-73-8	None	None	None	Semi-volatiles - 8270 – GCMS	0.1	0.5	3.3	5	[k]	[k]	[k]	[k]
Total organic carbon	TOC	N/A	N/A	None	TOC - 9060- combustion	1	1	100	100	+-20%	70-130%	+-35%	70-130%

[a]The preliminary action level is the regulatory or risk-based value used to determine appropriate analytical requirements (e.g., detection limits). Remedial action levels will be proposed in the FS, finalized in the ROD, and will drive remediation of the sites.
[b]RR = rural residential, C/I = commercial industrial, GW = groundwater protection radionuclide values from Washing State Department of Health's (WDOH's) *Hanford Guidance for Radiological Cleanup* (WDOH 1983). Radionuclide values are calculated using parameters from WDOH guidance.
[c]The "100 times groundwater" rule does not apply to residual radionuclide contaminants. For radionuclides, groundwater protection is demonstrated through technical evaluation using RESRAD.
[d]All four-digit numbers refer to test methods for evaluating solid waste physical/chemical methods (EPA 1986).
[e]Water values for sampling quality control (e.g., equipment blanks/rinses) or drainable liquid (if recovered).
[f]If quantitation to action level lower than nominal reliable detection level is required, prior notification/concurrence with the laboratory will be required to address special low-level detection limits.
[g]*Model Toxics Control Act* (MTCA) Method B soil values for direct exposure.
[h]MTCA Method C industrial soil values for direct exposure.
[i]MTCA Method B soil values for groundwater protection.
[j]Based on Federal Primary Drinking Water Standards (40 CFR 141), which is more restrictive than MTCA.
[k]Precision and accuracy requirements as identified and defined in the referenced EPA procedures.
[l]Value based on chromium (III) MTCA soil concentrations.
[m]Based on EPA's *Integrated Exposure Uptake Biokinetic Model for Lead in Children* (EPA 1994c).
[n]This value is based on the *Model Toxic Control Act* Method A values.
[o]Based on 100 times the National Primary Drinking Water Regulations action level.
[p]Value based upon nickel or uranium soluble salts value.
[q]Based on a proposed drinking water standard.
[r]From *Methods of Analysis of Water and Waste* (EPA 1983).
AEA = alpha energy analysis
CAS = Chemical Abstract Services
CVAA = cold vapor atomic absorption
GC = gas chromatograph
GCMS = gas chromatograph/mass spectrometry
GPC = gas proportional counter
IC = ion chromatography
ICPMS = inductively coupled plasma mass spectrometer
N/A = not applicable
TBD = to be determined
TOC = total organic carbon
VOA = volatile organic analysis

Table A-5. Sample Preservation, Container, and Holding Time Guidelines. (2 Pages)

Analytes	Analytical Priority	Matrix	Bottle		Amount[a,b,c]	Preservation	Packing Requirements	Holding Time
			Number	Type				
Radionuclides								
Americium-241	11	Soil	1	G/P	10-1000 g	None	None	6 months
Carbon-14	8	Soil	1	G/P	10-1000 g	None	None	6 months
Cesium-137	1	Soil	1	G/P	100-1500 g	None	None	6 months
Cobalt-60	1	Soil	1	G/P	100-1500 g	None	None	6 months
Europium-152	1	Soil	1	G/P	100-1500 g	None	None	6 months
Europium-154	1	Soil	1	G/P	100-1500 g	None	None	6 months
Europium-155	1	Soil	1	G/P	100-1500 g	None	None	6 months
Tritium – H3	18	Soil	1	G	100-500 g	None	None	6 months
Neptunium-237	7	Soil	1	G/P	10-1000 g	None	None	6 months
Nickel-63	7	Soil	1	G/P	10-1000 g	None	None	6 months
Plutonium-238	5	Soil	1	G/P	10-1000 g	None	None	6 months
Plutonium-239/240	5	Soil	1	G/P	10-1000 g	None	None	6 months
Strontium-90	2	Soil	1	G/P	10-1000 g	None	None	6 months
Technetium-99	7	Soil	1	G/P	10-1000 g	None	None	6 months
Thorium-232	6	Soil	1	G/P	10-1000 g	None	None	6 months
Uranium-234	3	Soil	1	G/P	10-1000 g	None	None	6 months
Uranium-235	3	Soil	1	G/P	10-1000 g	None	None	6 months
Uranium-238	3	Soil	1	G/P	10-1000 g	None	None	6 months
Chemicals								
Ammonia/ Ammonium – 350.1	14	Soil	1	G/P	50-500 g	None	Cool 4°C	28 days
Conductivity – 9050	15	Soil	1	G/P	200 g	None	Cool 4°C	28 days
IC 353.1 and EPA 300.0	7	Soil	1	G/P	50-500 g	None	None	28 days/ 48 hours
ICP metals – 6010A (Add-on)	4	Soil	1	G/P	10-500 g	None	None	6 months
ICP metals – 6010A (TAL)	4	Soil	1	G/P	10-500 g	None	None	6 months
Chromium hex – 7196	14	Soil	1	G/P	5-500 g	None	Cool 4°C	30 days
Mercury – 7471 – (CV)	13	Soil	1	G	5-125 g	None	None	28 days
Total cyanide – 9010	16	Soil	1	G	10-1000 g	None	Cool 4°C	14 days
pH (soil) – 9045	17	Soil	1	G/P	10-250 g	None	None	ASAP
SVOA – 8270A (TCL)	9	Soil	1	aG	125-1000 g	None	Cool 4°C	14/40 days
Total organic carbon - 9060	10	Soil	1	G	125-250 g	None	Cool 4°C	14 days
Non-halogenated VOA – 8015M	19	Soil	1	G	10-50 g	None	Cool 4°C	14 days
Herbicides - 8151A	WM	Soil	1	aG	250 g	None	Cool 4°C	14/40 days
Physical Properties								
Bulk density – D2937	20	Soil	1	Liner	1,000 g	None	None	None established for analysis
Moisture content – ASTM D2216	21	Soil	1	Moisture Tin[d]	250 g	None	None	None established for analysis

Table A-5. Sample Preservation, Container, and Holding Time Guidelines. (2 Pages)

Analytes	Analytical Priority	Matrix	Bottle		Amount[a,b,c]	Preservation	Packing Requirements	Holding Time
			Number	Type				
Particle size distribution – ASTM D422	22	Soil	1	G/P	TBD	None	None	None established for analysis

[a]Optimal volumes, which may be adjusted downward to accommodate the possibility of retrieval of small amount of sample. Minimum sample size will be defined in the Sampling Authorization Form.
[b]Should samples be liquid rather than soils, the following volumes need to be collected: *Radionuclides*-4 L (preserved in nitric acid) for all radionuclides (except carbon-14 and tritium require no preservation, and technetium-99 must be preserved in hydrochloric acid; they require approx. 500 mL each sample); *Chemicals*-all liquid samples require the amount as listed for soil samples.
[c]Mixed soil samples may be obtained and submitted to the analytical laboratory for analyses for specific analytes including: *Radionuclides*-100 g of soil for all radionuclides (except carbon-14, tritium, and technetium-99; they require approx. 10 g each sample); *Chemicals*-a 10-g soil sample is required for all ICP analysis, 10-g soil sample is required for IC anion analysis, 5-g soil sample for hexavalent chromium analysis, 10-g soil sample for CA analysis, 10-g soil sample for 8015 analysis, and 125-g soil samples for each 8270 and TOC analyses.
[d]Vessel must be sealed.

aG = amber glass
ASAP = as soon as possible
CV = cold vapor
G = glass
P = plastic
SVOA = semi-volatile organic analyte
TAL = target analyte list
TBD = to be determined
TCL = target compound list
VOA = volatile organic analyte
WM = waste management sample

A.3 FIELD SAMPLING PLAN

A.3.1 Sampling Objectives

The primary objective of the field sampling plan (FSP) is to clearly identify and describe sampling and analysis activities that will be conducted to resolve decision rules identified in Step 5 of the DQO process (see Section A.1.5.2). Decision rule statements indicate that remedial action may be necessary if preliminary action levels and annual exposure protection limits are exceeded. The FSP uses the sampling design proposed in Step 7 of the DQO process and describes pertinent elements of the sampling program. Sample methods, procedures, locations, frequencies, parameters of interest, and bottle requirements are identified in this section.

A borehole will be drilled through each of the representative sites identified in the DQO as needing additional data to support the RI/FS process: the 216-T-26 Crib, the 216-B-7A Crib, and the 216-B-38 Trench. The boreholes will be drilled to groundwater and soil samples will be collected through the entire vadose zone for laboratory analysis. Physical property samples will be collected at major lithologic changes. The boreholes will be geophysically logged for gamma-emitting radionuclides and neutron moisture content. A spilt-spoon sampler will be the primary sampling device used to collect the samples from the boreholes. The locations of planned and existing boreholes are shown in Figures A-1 through A-3.

A.3.2 Field Measurements

A.3.2.1 Surface Radiation Survey. A surface radiation survey will be performed at each waste site to be investigated to document existing surface contamination and to support preparation of supporting health and safety documentation. Surface radiation surveys will be conducted by qualified RCTs in accordance with applicable health and safety procedures. A survey report will be prepared for each site. Surveys will be performed according to BHI-EE-05, Procedure 2.5, "Operation of Mobile Surface Contaminant Monitor II," or other applicable approved procedures. A post-sampling survey will also be performed at each sampling site to ensure that sampling activities have not contributed to surface contamination.

A.3.2.2 Soil Screening. All samples and cuttings from boreholes will be field screened for evidence of radioactive contamination by the RCT or other qualified personnel. Surveys of these materials will be conducted visually and with field instruments. Potential screening instruments are listed in Table A-6 with their respective detection limits. The RCT will record all field measurements, noting the depth of the sample and the instrument reading.

Prior to drilling, a local area background reading will be taken with the field screening instruments at a background site to be selected in the field. Field screening will be used to identify the bottom of the waste site (i.e., crib/trench) and adjust sampling points, assist in determining sample shipping requirements, and support worker health and safety monitoring. The site geologists will use professional judgment, screening data, and the information provided in Tables A-7 through A-9 to finalize sampling decisions.

The field action level for radionuclide screening is twice background. Intervals above this field action level will be assessed for sampling by the field geologist. Samples exceeding 0.5 mrem/hr will be stored at a temporary radioactive material storage area until shipment to the laboratory.

Field screening instruments will be used, maintained, and calibrated in accordance with the manufacturer's specifications and other approved procedures. The field geologist will record field screening results on the borehole log.

A.3.3 Soil Sampling and Analysis

The following sections discuss the details of sampling soil from boreholes.

A.3.3.1 Borehole Sampling and Analysis. Nonradiological and radiological samples will be collected from three deep boreholes. Borehole C3102 will be drilled in the 216-T-26 Crib. Borehole C3103 will be in drilled in the 216-B-7A Crib. Borehole C3104 will be drilled in the 216-B-38 Trench. The trench is unique because the borehole location will be determined through a series of direct push holes that will be geophysically logged to determine the area of the ditch with the highest contamination from gamma-emitting radionuclides. This step is necessary as historical information is not available concerning the release point of the effluent to the trench. Borehole sample collection will be guided by the sampling approaches outlined in Tables A-7, A-8, and A-9. Actual sampling intervals may vary from these approaches depending on the thickness of clean soil cover placed over the cribs and trench. The intent of the sampling design is to begin sample collection at the crib/trench bottom and continue sampling intermittently (based on the site's conceptual contaminant distribution model, results of nearby borehole logging events, and professional judgement of the field geologist) until a significant decrease in contamination is noted. The zone of highest expected contamination will likely contain low mobility contaminants. Additional samples above and below this zone of highest contamination will be collected based on characteristics exhibited during the field screening activities and geologic observations. Figures A-4 through A-6 illustrate hypothetical sampling intervals in boreholes.

The bottoms of the waste sites are considered critical sample points because the highest levels of contamination are expected to begin at this location. Samples from 4.6 m (15 ft) below ground surface (bgs) and 7.6 m (25 ft) bgs are also considered critical sampling points to evaluate exposure scenarios and remedial alternatives. Sample from depths greater than 7.6 m (25 ft) bgs will be used to verify the conceptual contaminant distribution models and to evaluate remedial action alternatives and groundwater impacts. Drilling and sampling will stop when the water table is encountered.

Sampling will be performed in accordance with BHI-EE-01, Procedure 4.0, "Soil and Sediment Sampling," using a split-spoon sampler. The split-spoon samplers will be equipped with four separate stainless steel or lexan liners. Site personnel will not overdrive the sampling device. With the exception of the co-located duplicate samples, soil will be transferred to a pre-cleaned, stainless steel mixing bowl, homogenized, then containerized in accordance with the sampling procedure. Radiological and nonradiological analytes of interest are presented in Table A-4. If sample volume requirements cannot be met, samples will be collected according to the priority

presented in Table A-4. Radiological and nonradiological samples will always take precedence over physical property samples.

Physical property samples will be collected from the boreholes to provide site-specific values to support RESidual RADioactivity (RESRAD) dose model or other modeling efforts. Soil properties of interest are moisture content, grain-size distribution, and soil density. Samples for soil density shall generally be collected with a split-spoon sampler equipped with four separate stainless steel or lexan liners. Samples will be analyzed in accordance with ASTM methods, listed in Table A-4 (ASTM 1993). The physical property samples will be collected from lithologies that represent the major facies in the vadose zone as identified in Tables A-7 and A-9. The samples will be collected coincident with nonradiological and radiological split-spoon sample intervals, where possible. Additional samples may be obtained with the approval of the project manager.

Investigation-derived waste generated during this activity will be handled according to procedures in Section A.2 and the waste control plan.

A.3.3.2 Pre-Shipment Sample Screening. A representative portion of each sample to be shipped to an offsite laboratory will be submitted to the RCF, 222-S Laboratory, or other suitable onsite laboratory for total activity analysis prior to shipment. Total activities will be utilized for sample pre-shipment characterization. Samples that slightly exceed the offsite laboratory criterion discussed in Section A.3.2.2 may be reduced in volume to allow offsite shipment. Onsite and offsite laboratories will be identified prior to initiating field activities and will be mutually acceptable to the ERC's Sample and Data Management group and to the task lead.

A.3.3.3 Summary of Sampling Activities. A summary of the number and types of samples to be collected at all three waste sites is presented in Table A-10.

A.3.4 Geophysical Logging

The planned boreholes and selected existing boreholes will be geophysically logged with the high-resolution spectral gamma-ray logging system to determine the vertical distribution and concentration of gamma-emitting radionuclides. Soil moisture will also be determined using a neutron logging tool. These methods are described in Section 4.3 of the work plan. The new boreholes will be logged prior to telescoping of casing and before abandonment. The starting point for logging will be recorded; this is usually ground surface or top of casing. The site geologist will witness logging runs and verify before and after field calibrations and repeat log intervals. The list of boreholes and wells that will be logged with the radionuclide logging system is presented in Table A-11. These wells represent data collection points in the vicinity of the individual waste sites. Logging of these wells will provide additional, updated, site-specific information on contaminant distribution, both laterally and vertically in the area of the waste sites.

A.3.5 Surveying

The location of all planned boreholes will be surveyed after the sampling and abandonment activities are completed. Surveys will be performed according to BHI-EE-01, Procedure 1.6, "Survey Requirements and Techniques." Data will be recorded in the North American Vertical

Datum of 1988 (NAVD 1988) and the Washington State Plane (South Zone) North American Datum of 1983 (NAD 1983), with the 1991 adjustment for horizontal coordinates. All survey data will be recorded in meters and feet.

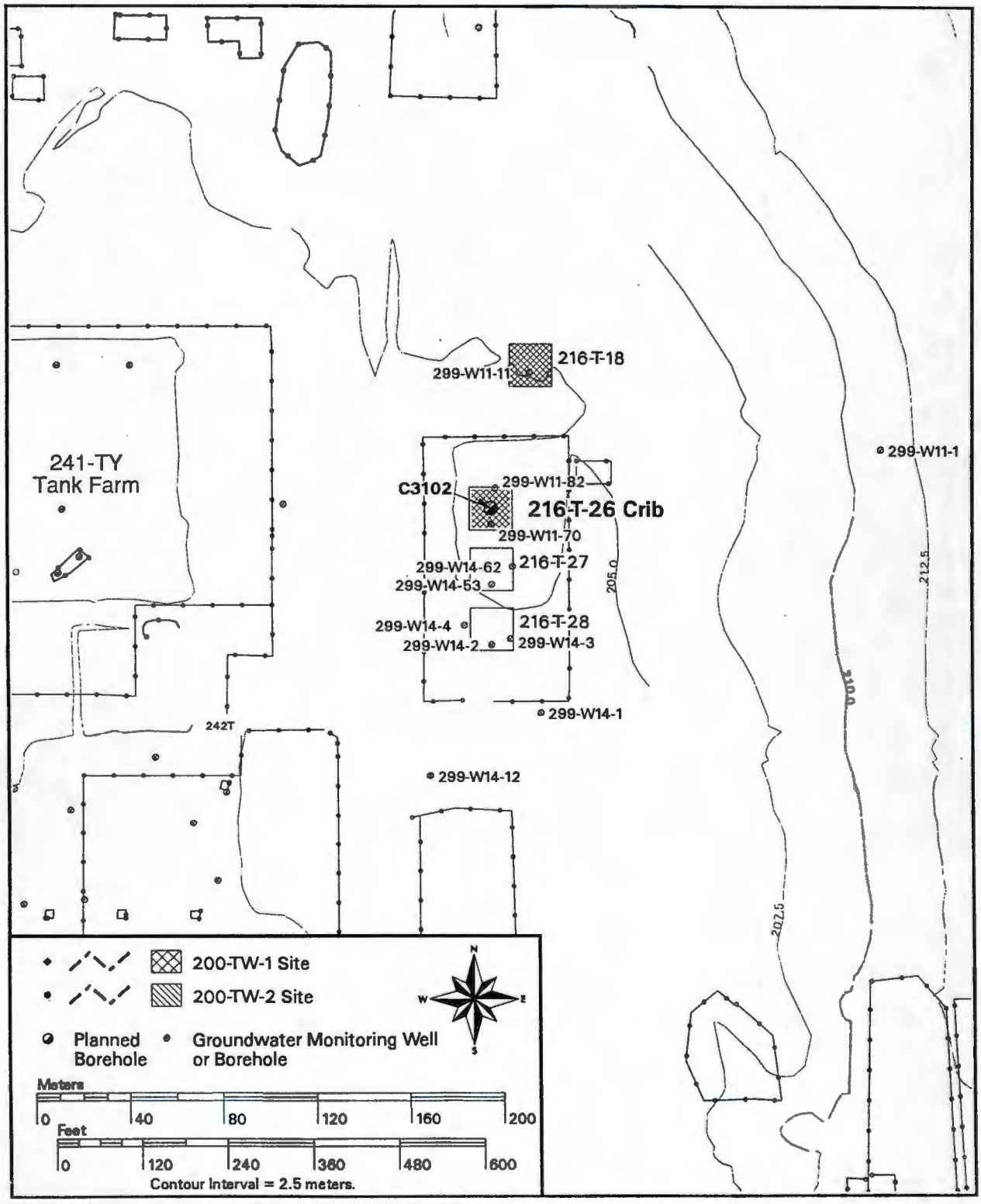
A.3.6 Waste Management Sampling

A DQO process was conducted to identify additional sampling that may be required to support waste management of the investigation-derived waste generated from the field sampling activities. The DQO process included review of the COPCs identified for the 200-TW-1 and 200-TW-2 OUs and an analysis of any additional constituents that should be evaluated to complete the waste designation and profile. Based on the results of the waste management DQO, additional samples are required as listed in Table A-12. Table A-13 details the additional samples identified and the corresponding analytical requirements. Bottle requirements have been included in Table A-5.

A.3.7 Science and Technology Program Sampling Requirements

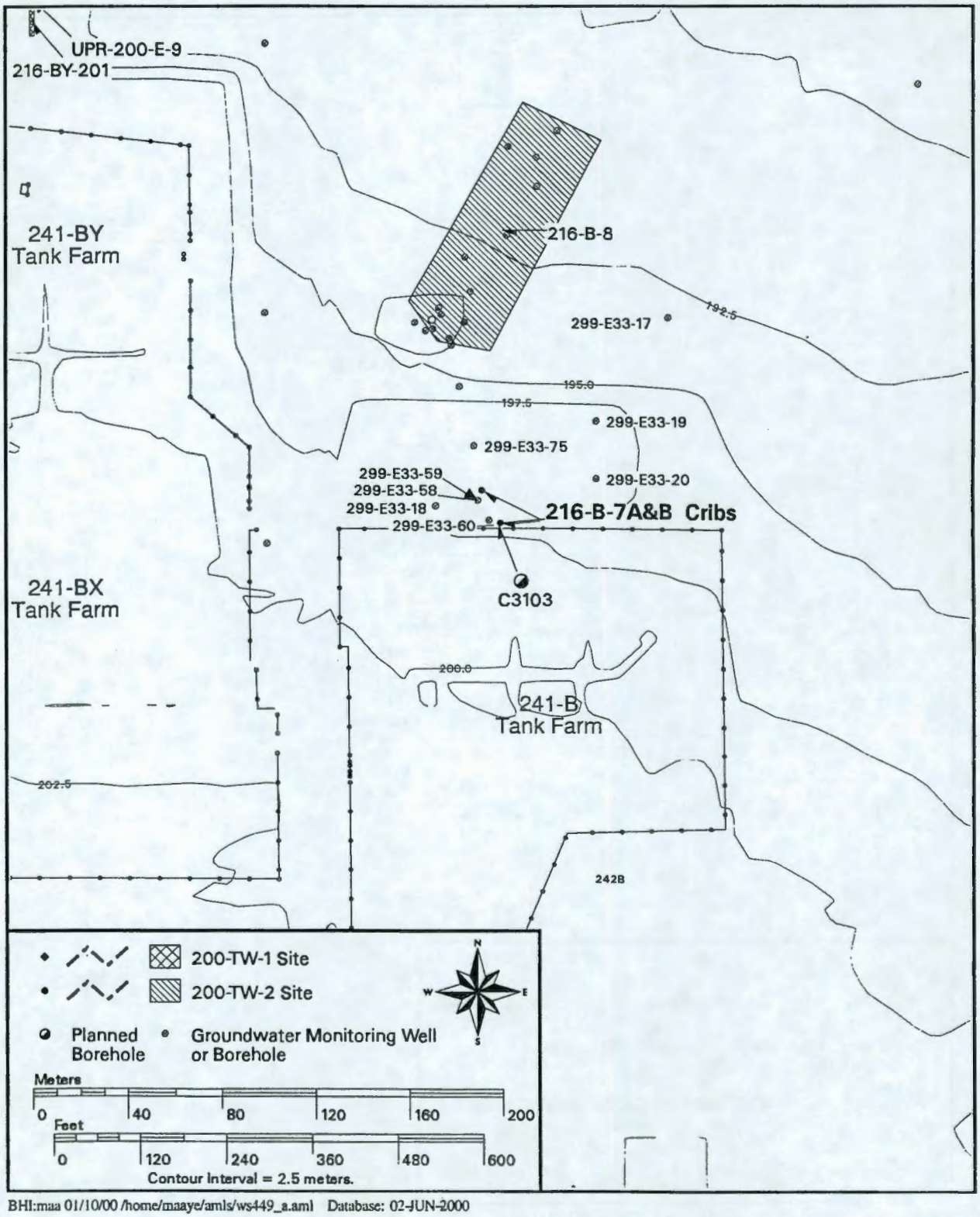
The Hanford Vadose Zone Science and Technology Program (S&T) has requested sample material from the remedial investigation at the 216-B-7A Crib to use in studying the mineralogic association, desorption rates, and solubility of plutonium in sediments contaminated with tank waste from the lanthanum-fluoride and bismuth-phosphate processes. Approximately 0.5 kg of soil has been requested from each of five borehole sampling intervals between approximately 6.7 to 12 m (22 to 40 ft) bgs, the area directly below the crib and the presumed depth range of plutonium localization. As a result, the 200 Area Remedial Action Project, under this work plan, may collect additional soil samples for the S&T Program. Chains of custody will be prepared when the samples are collected, and samples will be transferred to the S&T Program following sample collection. Once samples are transferred, S&T will be responsible for sample management, storage, analysis, and disposal according to their own sample management, disposition, and waste management plan. This plan will be prepared by the S&T Program and approved by DOE and the appropriate regulatory agencies prior to sample collection by the 200 Area Remedial Action Project. Sample collection is contingent on availability of S&T funding to support collection and analysis. This will be communicated to the sampling team prior to the date of sample collection.

Figure A-1. Location of Planned and Existing Boreholes and Wells at the 200-TW-1 216-T-26 Crib.



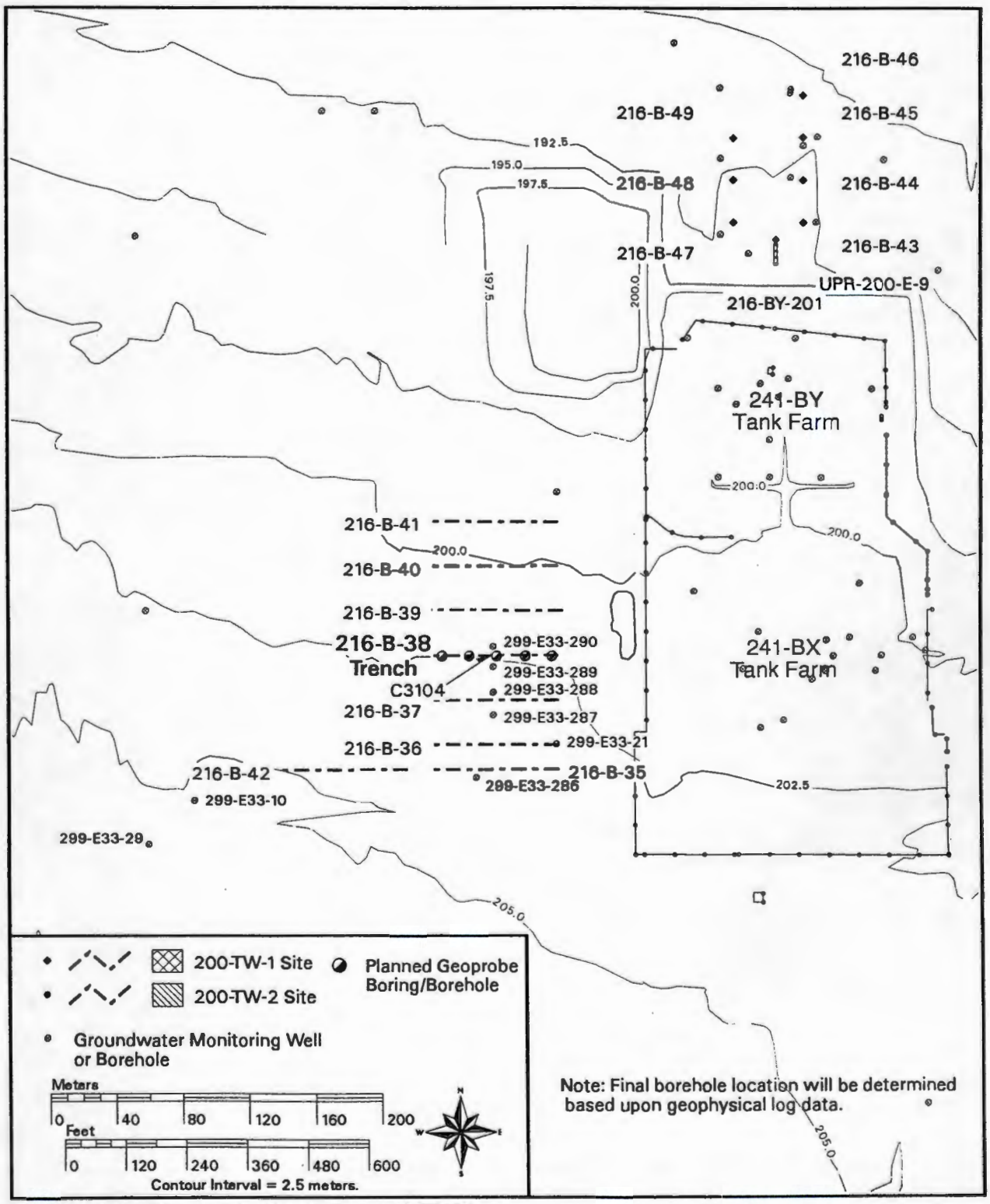
BHI:maa 1/10/00 /home/maaye/amls/ws516_a.aml Database: 02-JUN-2000

Figure A-2. Location of Planned and Existing Boreholes and Wells at the 200-TW-2 216-B-7A&B Cribs.



BHI:maa 01/10/00 /home/maaye/amls/ws449_a.aml Database: 02-JUN-2000

Figure A-3. Location of Planned and Existing Boreholes and Wells at the 200-TW-2 216-B-38 Trench.



BHI:maa 01/05/00 /home/maaye/amls/ws414_a.aml Database: 22-FEB-2001

Figure A-4. Approximate Sampling Intervals in the 216-T-26 Borehole.

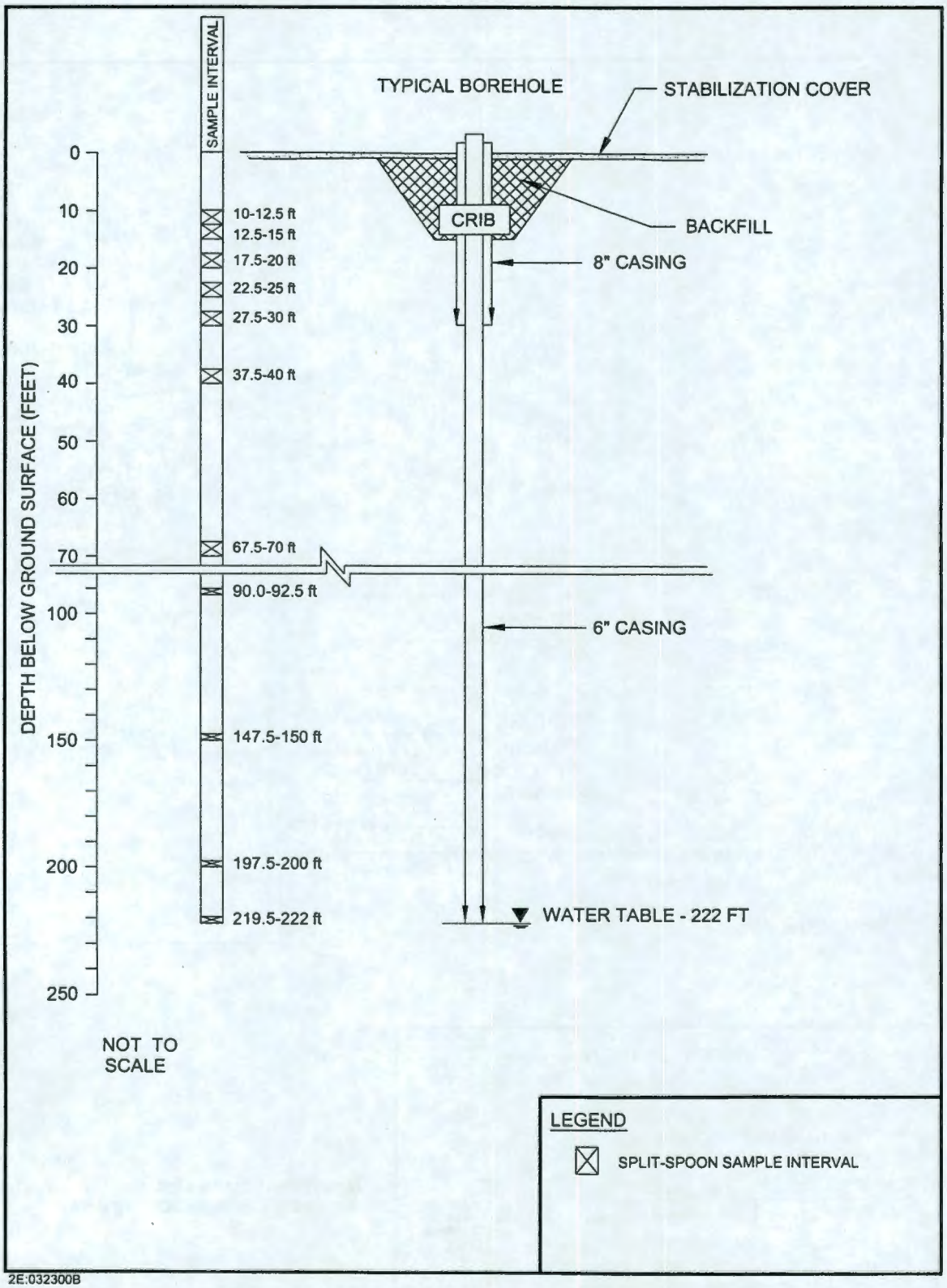


Figure A-5. Approximate Sampling Intervals in the 216-B-7A Borehole.

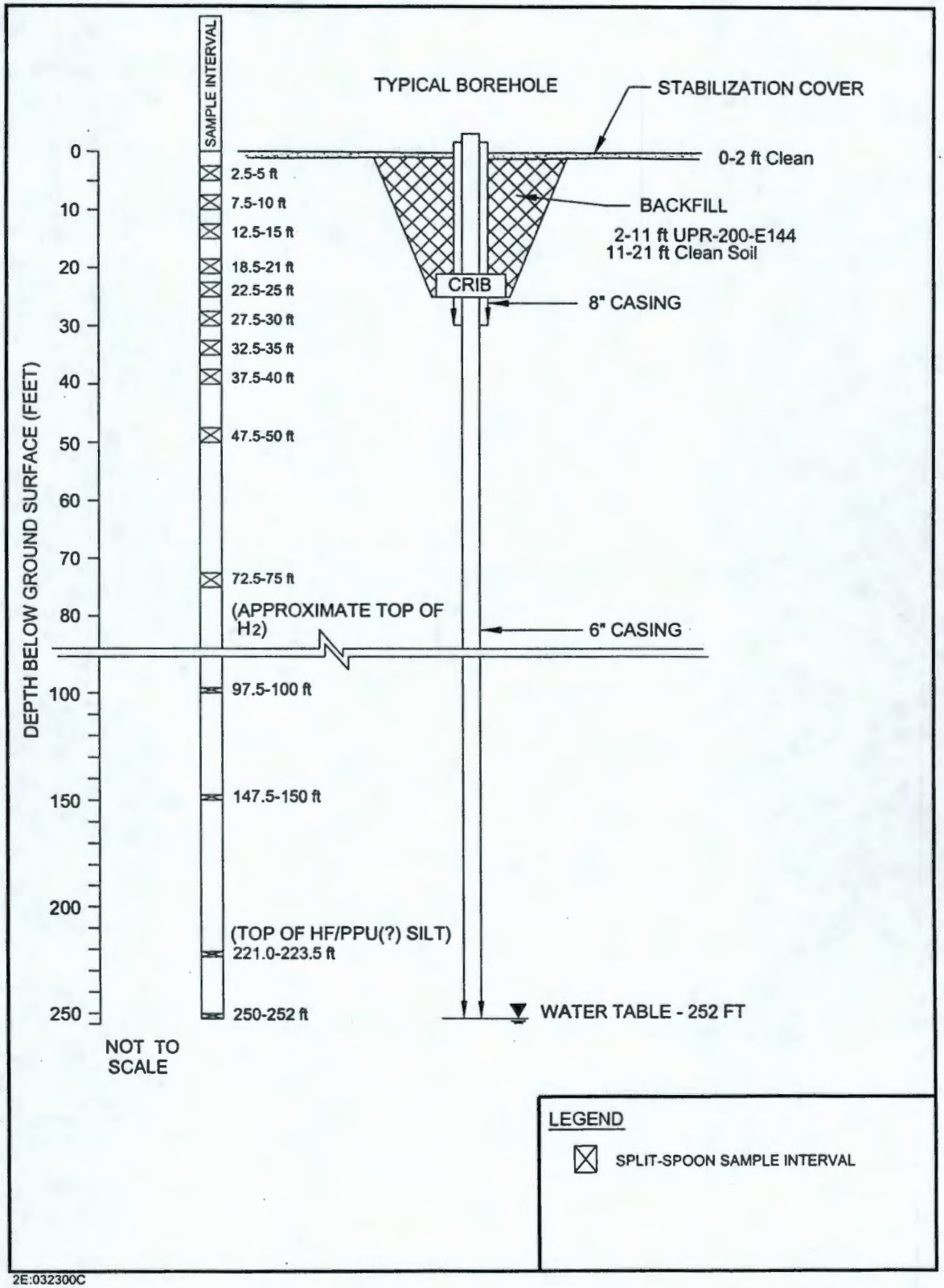


Figure A-6. Approximate Sampling Intervals for the 216-B-38 Borehole.

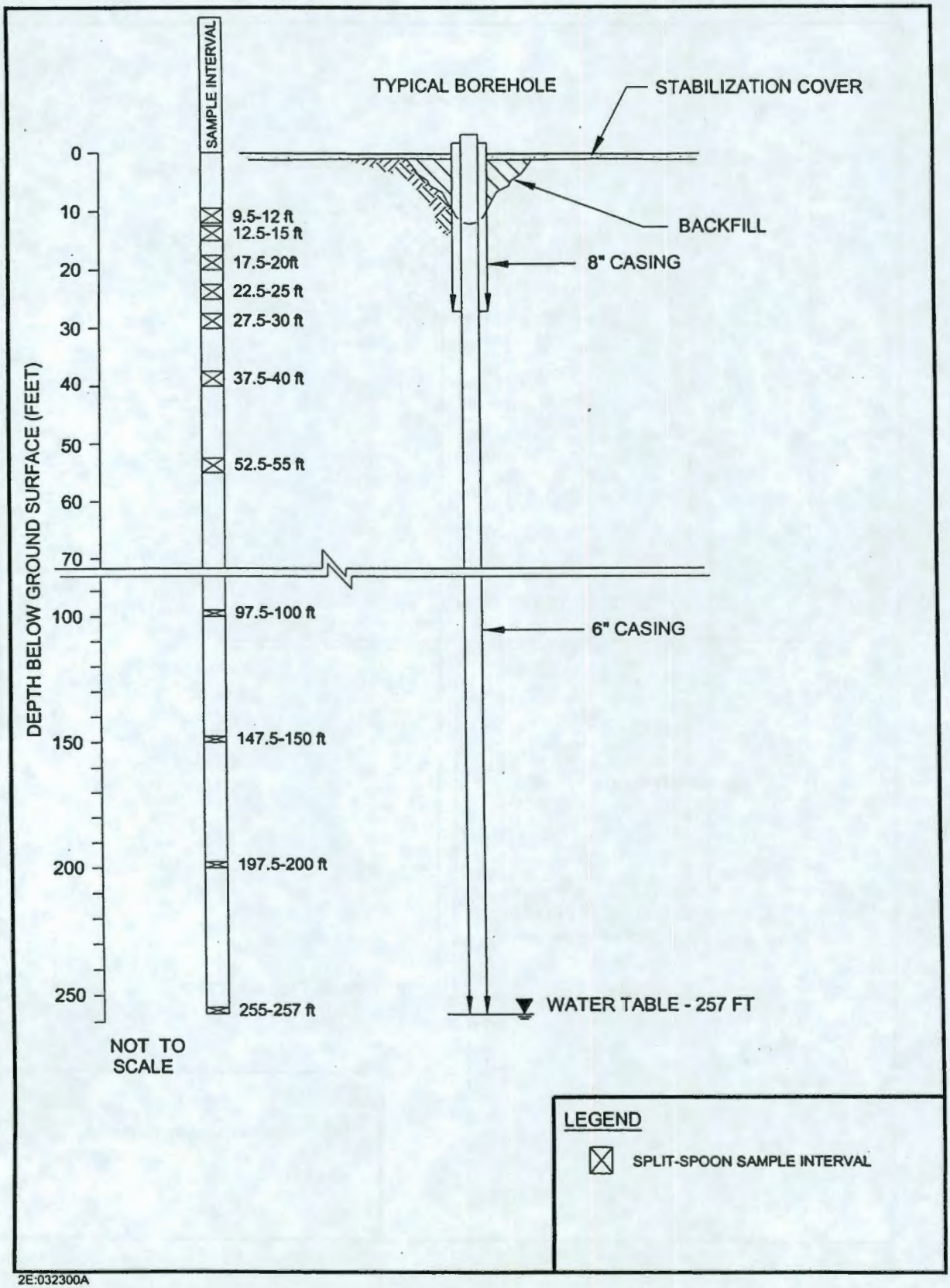


Table A-6. Field Screening Methods.

Measurement Type	Emission Type	Method/Instrument	Detection Limit
Exposure/Dose Rate	Beta/gamma	RO-20/RO-03 portable ionization chamber	0.5 Mr/hr
Contamination Level	Alpha/beta-gamma	E-600 ratemeter with a SHP380-A/B scintillation probe	100 dpm α 1,921 dpm β–γ

Table A-7. 216-T-26 Crib Sampling Plan.

Sample Collection Methodology	Sample Location	Maximum Depth of Investigation	Sample Interval Depth (ft) bgs	Analyte List[a]	Physical Properties	
					Sample Interval (bgs)	Parameters
Borehole C3102	C3102	222 ft bgs	10-12.5, 12.5-15, 17.5-20, 22.5-25, 27.5-30, 37.5-40, 67.5-70, 90.0-92.5, 147.5-150, 197.5-200, 219.5-222	Table A-4	1 sample from each of the following: • H_1 • H_2 • PPU/EPS • Upper Ringold • Ringold Unit E	Bulk density, moisture content, particle size distribution
Maximum Number of Samples		11				
Approximate Number of Field QC Samples		3[b]				
Approximate Total Number of Samples		14				

bgs = below ground surface
H_1 = Hanford formation Upper Gravel Sequence
H_2 = Hanford formation Sandy Sequence
PPU/EPS = Plio-Pleistocene Unit/Early Palouse Soil
[a] See Table A-4 for detection limits and other analytical parameters.
[b] See Table A-11 for details of QC samples.

Table A-8. 216-B-7A Crib Sampling Plan.

Sample Collection Methodology	Sample Location	Maximum Depth of Investigation	Sample Interval Depth (ft) bgs	Analyte List[a]	Physical Properties	
					Sample Interval (bgs)	Parameters
Borehole C3103	C3103	252 ft	2.5-5, 7.5-10, 12.5-15, 18.5-21, 22.5-25, 27.5-30, 32.5-35, 37.5-40, 72.5-75, 97.5-100, 147.5-150, 221.0-223.5, 250-252	Table A-5	1 sample from each of the following: • H_1 • H_2 • HF/PPU (?) Silt • HF/PPU (?) Gravel	Bulk density, moisture content, particle size distribution
Maximum Number of Samples		13				
Approximate Number of Field QC Samples		3[b]				
Approximate Total Number of Samples		16				

Bgs = below ground surface
H_1 = Hanford formation Upper Gravel Sequence
H_2 = Hanford formation Sandy Sequence
HF/PPU (?) Silt = Hanford formation/Plio-Pleistocene Unit (?) Silt
HF/PPU (?) Gravel = Hanford formation/Plio-Pleistocene Unit (?) Gravel
[a] See Table A-4 for detection limits and other analytical parameters.
[b] See Table A-11 for details of QC samples.

Table A-9. 216-B-38 Trench Sampling Plan.

Sample Collection Methodology	Sample Location	Maximum Depth of Investigation	Sample Interval Depth (ft) bgs	Analyte List[a]	Physical Properties	
					Sample Interval (bgs)	Parameters
Borehole C3104	C3104	252 ft	9.5-12, 12.5-15, 17.5-20, 22.5-25, 27.5-30, 37.5-40, 52.5-55, 97.5-100, 147.5-150, 197.5-200, 255-257	Table A-5	1 sample from each of the following: • H_1 • H_2 • HF/PPU (?) Gravel	Bulk density, moisture content, particle size distribution
Maximum Number of Samples		11				
Approximate Number of Field QC Samples		3[b]				
Approximate Total Number of Samples		14				

bgs = below ground surface
H_1 = Hanford formation Upper Gravel Sequence
H_2 = Hanford formation Sandy Sequence
HF/PPU (?) Gravel = Hanford formation/Plio-Pleistocene Unit (?) Gravel
[a] See Table A-4 for detection limits and other analytical parameters.
[b] See Table A-11 for details of QC samples.

Table A-10. Summary of Projected Sample Collection Requirements.

	216-T-26 Crib	216-B-7A Crib	216-B-38 Trench	Project Total
Chemical Parameters				
Maximum number of characterization samples	11	13	11	35
Detail of QC samples				
Collocated duplicates	1	1	1	3
Splits	1	1	1	3
Equipment blanks	1	1	1	3
Approximate number of field QC samples	3	3	3	9
Approximate total number of samples	14	16	14	44
Physical Properties				
Bulk density, moisture content, particle size distribution	5	4	3	12

Table A-11. List of Boreholes for Spectral Gamma Ray Logging.

Borehole Number	Approximate Location	Coordinates (Wash. State Plane, NAD83[91])	
		Northing	Easting
C3102[a]	Within the boundaries of the 216-T-26 Crib	TBD	TBD
C3103[a]	Within the boundaries of the 216-B-7A Crib	TBD	TBD
C3104[a]	Within the boundaries of the 216-B-38 Trench; will also log direct push holes to help define borehole location	TBD	TBD
299-W11-70	South edge of 216-T-26	136392.107	566932.165
299-W11-82	North edge of 216-T-26	136407.518	566933.853
299-E28-7	Southeast of 216-B-5	136719.127	573794.205
299-E28-23	Adjacent to 216-B-5	136730.748	573781.892
299-E28-24	Southeast of 216-B-5	136727.768	573785.436
299-E28-25	Northwest of 216-B-5	136736.730	573776.927
299-E33-19	Northeast of 216-B-7A&B	137422.659	573847.630
299-E33-20	East of 216-B-7A&B	137397.913	573847.598
299-E33-58	Northwest of 216-B-7B	137388.475	573797.295
299-E33-60	South of 216-B-7A	137379.963	573802.064
299-E33-75	North of 216-B-7B	137412.003	573795.536

NOTE: Initial selection of existing wells was based on a review of well construction as-built diagrams. A single casing in contact with the formation is the preferred configuration for logging. A field inspection of the well configuration will be performed for final selection of boreholes. No logging of existing boreholes at 216-B-38 is planned because boreholes in this area were recently logged.
[a] Planned boreholes.

Table A-12. Key Features of the 200-TW-1 and 200-TW-2 Sampling Design.

Sample Collection Methodology	Key Features of Design	Basis for Sampling Design
Bismuth		
Borehole characterization at each waste site	Collect one soil samples at the bottom of the trench/crib	Biased sampling at worst case location based on site conceptual models. Sampling provides data for waste characterization decision making.
Herbicides		
Surface soil characterization at each waste site	Collect one surface sample (0 – 6 in.) at the surface the waste site	Biased sampling at surface based on application methods. Sampling provides data for waste characterization decision making.

Table A-13. Waste Management Sample Requirements.

CAS #	COCs	Survey or Analytical Method	Action Level	PQL (mg/kg)	Precision Required	Accuracy Required
7440-69-9	Bismuth	ICP Metals – EPA Method 6010[a]	b	10	±30	70-130
75-99-0	2,2-Dichloropropionic acid (Dalapon)	EPA Method 8151A	c	0.1	±30	70-130
1918-00-9	Dicamba	EPA Method 8151A	b,c	0.1	±30	70-130
120-36-5	2-(2,4-dichlorophenoxy)propionic acid (Dichloroprop)	EPA Method 8151A	b,c	0.1	±30	70-130
94-75-7	2,4-Dichlorophenoxy acetic acid	EPA Method 8151A	200 mg/kg[b,c]	0.4	±30	70-130
93-72-1	2,4,5-TP (Silvex)	EPA Method 8151A	20 mg/kg[b,c]	0.02	±30	70-130
93-76-5	2,4,5-Trichlorophenoxyacetic acid	EPA Method 8151A	b,c	0.02	±30	70-130
94-82-6	2,4-Dichlorophenoxybutyric acid (2,4-DB)	EPA Method 8151A	b,c	0.1	±30	70-130
93-65-2	(2 methyl-4-chlorophenoxy) 2-propionic acid (MCPP)	EPA Method 8151A	b,c	10	±30	70-130
94-74-6	2-methyl-4-chlorophenoxy acetic acid (MCPA)	EPA Method 8151A	b	10	±30	70-130

[a]Bismuth will be an additional requested constituent from EPA Method 6010.
[b]Washington State toxic. Equivalent concentration of all toxic compounds greater than 0.001% by weight.
[c]Total concentration for halogenated organics greater than 0.01% by weight.
CAS = Chemical Abstract Services
PQL = practical quantitation limit

A.4 HEALTH AND SAFETY

All field operations will be performed in accordance with BHI health and safety requirements outlined in BHI-SH-01, *ERC Safety and Health Program*, and in accordance with the requirements of the *Hanford Site Radiological Control Manual* (DOE-RL 1996b). In addition, a work control package will be prepared in accordance with BHI-MA-02, *ERC Project Procedures*, which will further control site operations. This package will include an activity hazard analysis, site-specific health and safety plan, and applicable radiological work permits.

The sampling procedures and associated activities will take into consideration exposure reduction and contamination control techniques that will minimize the radiation exposure to the sampling team as required by BHI-QA-01, *ERC Quality Program*, and BHI-SH-01.

A.5 MANAGEMENT OF INVESTIGATION-DERIVED WASTE

Investigation-derived waste generated by characterization activities will be managed in accordance with BHI-EE-10, *Waste Management Plan*, and Appendix E of the Implementation Plan. Containment, labeling, and tracking requirements are specified in BHI-EE-10, Section 9.0, "Control of CERCLA and Other Past Practice Investigation Derived Waste." These procedures have been prepared to implement the requirements of the Washington State Department of Ecology, found in *Strategy for Management of Investigation Derived Waste* (Ecology et al. 1999). Management of investigation-derived waste, minimization practices, and waste types applicable to 200-TW-1 and 200-TW-2 waste control are described in the waste control plan.

Unused samples and associated laboratory waste for the analysis will be dispositioned in accordance with the laboratory contract, which in most cases will require the laboratory to dispose of this material. The approval of the remedial project manager is required before returning unused samples or waste from offsite laboratories.

A.6 REFERENCES

40 CFR 141, "National Primary Drinking Water Regulations," *Code of Federal Regulations*, as amended.

40 CFR 830.120, "Quality Assurance Requirements," *Code of Federal Regulations*, as amended.

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DOE-RL, 1996b, *Hanford Site Radiological Control Manual* (HSRCM), DOE/RL-96-109, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

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